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OF THE

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National Fire Protection Association

INTERNATIONAL

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Underwriters' Association of the District of Columbia.
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Western Actuarial Bureau (Fire).
Western Canada Insurance Underwriters' Association.
Western Factory Insurance Association.
Western Sprinkled Risk Association.
Western Underwriters Association.
West Virginia Fire Underwriters' Association.
West Virginia Inspection Bureau.

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Table of Contents.

BREVOORT APARTMENT HOUSE FIRE, BROOKLYN, N. Y. ..... FRONTISPIECE

EDITORIALS 289

MEETING OF BOARD OF DIRECTORS 293

U. S. FIRE LOSSES FOR 1932 AND 1933 295

FIRE CAUSE TRENDS 296

LYNCHBURG TRANSIENT BUREAU FIRE 301

FIRE PREVENTION AND MODERN MANUFACTURING. *H. L. Miner* 303

MOLASSES TANK EXPLOSIONS. *C. A. Browne* 310

ANDERSON STORE AND TELEPHONE EXCHANGE FIRE 316

MEASURING FOREST FIRE DANGER. *H. T. Gisborne* 323

PAULSBORO, N. J., LINOLEUM FACTORY FIRE 329

BIRMINGHAM DEPARTMENT STORE FIRE. *South-Eastern Underwriters Association* 335

BAKERY FIRE RECORD 346

FIRES IN WHICH THERE WAS LOSS OF LIFE 361

ANNUAL SPRINKLER TABLES 365

INDEX TO VOLUME XXVII 378

Reports of fires appearing in the Quarterly are copies of or extracts from written reports forwarded to the Association. This Association, as a body, is not responsible for the statements or opinions of any of its members.

The Brevoort apartment house, Brooklyn, N. Y., $200,000 fire of Dec. 31, 1933, was charged to the oil burning equipment in the basement. Fire spread rapidly upwards through the many pipe ducts and unprotected openings of this 8-story brick-joisted structure despite the best efforts of the New York fire department. Erected in 1900, the building was in poor repair and at the time of the fire the New York City Tenement House Department had 32 violations pending against the building.

The Quarterly

Vol. 27 April, 1934 No. 4

The Atlantic City Meeting. Atlantic City, "The World's Playground," paradoxically provides an environment that is peculiarly suited to the serious purpose of the annual meetings of the National Fire Protection Association. Members who have attended the N.F.P.A. conventions held in Atlantic City in alternate years since 1922 know that the pleasant atmosphere and freedom from distracting influences make possible that happy combination of attention to convention business and good fellowship among members that has been characteristic of our Atlantic City meetings. The meeting room floor of Haddon Hall, high above the ocean, was planned by our genial host, Mr. Albert T. Bell, with particular reference to the N.F.P.A. conventions; nowhere else can we find meeting facilities or hotel accommodations better suited to our needs. Outside is the Boardwalk, delightful in mid-May, inviting a walk or wheeled chair ride with friends.

The science of fire prevention and fire protection is constantly developing; every year new hazards, new methods of protection, new ways of meeting old problems are presented in committee reports and addresses at the N.F.P.A. meetings. The reports and papers are recorded in the Proceedings to make them available to all members, but only those who attend the convention can secure the real benefit of a meeting such as this which consists not only in the technical and educational material presented, but in the inspiration of actual participation and personal contact with the leaders in fire prevention and fire protection from all parts of the country.

* * * * *

The Revolution in Atlantic City. The Royal Palace has been destroyed. The Bolsheviks didn't do it. It wasn't even in Russia. Law-abiding citizens tore it down. It was in Atlantic City. It was a hotel. For several months from day to day it looked more and more like nothing at all, until now the boys are playing marbles on its site with the blue sky as the limit. Destruction usually doesn't make for repose of spirit; but this destruction did. Gentlemen whose condition in life was responsible for their sleeping in the vicinity of the Royal Palace may now awaken in the night without looking at the ceiling for the fire glare which the Royal Palace was qualified to furnish. Vacant lots do not usually start conflagrations.

Albert Bell, who has been chairman of the Board of Directors of the N.F.P.A. for so many years that he believes fire-traps will burn, had a friend in Atlantic City named Clifford Deacon. Clifford was the quiet sort of chap who would never make trouble for anybody unless he thought it was right and proper and then he would make plenty. Albert took Clifford for a walk one day and showed him about a hundred vacant and dilapidated buildings any one of which if a fire started on the right kind of night might burn the World's Greatest Playground to the ocean. He told Clifford that as he wasn't very busy just then he should go out and have these old buildings torn down.

If Mr. Deacon had been a city official he might have taken this as a criticism. Being merely a private citizen he took it as a compliment—and took it seriously. An old-time resident and business man, Curtis Eldredge, helped him make a survey. The mayor was interested, so was James Peterson, Superintendent of Buildings, and Joseph Leeds, Fire Chief; but nobody had any legal authority to start the revolution. They combined their efforts to get it, and on March 16, 1933, Mayor Bacharach signed an ordinance to take immediate effect providing for the removal or destruction of any building, wall or structure which is or may become dangerous to life or health and which might tend to extend a conflagration, "and to assess the cost thereof as a municipal lien against the premises." This last clause was quietly persuasive. Nothing will stimulate an American like a dollar.

Thus the Atlantic City revolution came, demolishing over eighty-five separate buildings in one year, and not even a cop interfered with it. There was the Royal Palace with its 300 rooms, the Blackstone with 400, the Lexington with 235, the old omnibus called the Charm Club, the Reading Railroad depot, and no end of other fire traps; and when the Federal government came around to see what all the shooting was about it bought Craig Hall, worse if anything than the Royal Palace itself, and began clearing the site for a new post office.

And so, with this record of unparalleled destruction resulting from their original conspiracy, Albert and Clifford sit as composedly drinking lemonade in Haddon Hall as if they had been organizing a Sunday School.

* * * * *

The Hakodate Conflagration. Hakodate, a city of 213,000 population in northern Japan, burned on March 22 with an appalling loss of life. Press dispatches report 1989 deaths recorded in an official tabulation some days after the conflagration. Some 23,000 buildings were destroyed, razing an area of six square miles of tinder-like frame construction. The fire started in an equinoctial gale that wrecked chimneys during a period of extreme cold, and burned through a night of indescribable horror. Caught between the approaching wall of flame and the icy waters of the harbor many

chose death by drowning, but most of the unfortunate victims were trapped by the racing flames and cremated. To those familiar only with fire conditions in the western hemisphere, where in most cases escape from a burning building to the street is synonymous with safety, it seems almost impossible to conceive the conditions of a Japanese city conflagration.

* * * * *

The Old Law Tenements. The New York Tenement House Law enacted in 1901 requires certain features of built-in fire safety, notably a minimum standard of construction and arrangement of stairways and their enclosures. It is significant that New York City Fire Department records include no report of any loss of life by fire in a "new law" tenement, chargeable in any way to the construction and arrangement of the building. While the records attest the safety of apartment and tenement buildings erected since 1901, fatal fires have continued in the old law tenements. Langdon W. Post, Tenement House Commissioner of New York City, says, "There are 67,000 old law fire trap homes that we know of in this city that have existed for thirty-five years at least." During the past winter the fire record of these old structures has been little short of appalling. Following is a list of these fires as reported by the press.

Date	Location	Construction	Killed
Nov. 3, 1933	361 Bristol St., Brooklyn	3-story frame	9
Dec. 1, 1933	617 9th Avenue	4-story brick	1
Dec. 3, 1933	359 West 50th Street	3-story stone	1
Dec. 10, 1933	32 Sumpter St., Brooklyn	2-story frame	1
Dec. 17, 1933	547 Lenox Avenue	5-story brick	1
Dec. 18, 1933	20 E. 130th Street	3-story brick	1
Dec. 25, 1933	273 W. 134th Street	4-story stone	3
Jan. 7, 1934	6015 5th Ave., Brooklyn	3-story brick	2
Feb. 7, 1934	349 E. 118th Street	5-story brick	2
Feb. 16, 1934	45 Prince St., Brooklyn	4-story brick	2
Feb. 17, 1934	40 E. 7th Street	5-story brick	8
Mar. 1, 1934	169 Carroll St., Brooklyn	5-story stone	5
Mar. 3, 1934	1109 2nd Avenue	4-story stone	2
Mar. 13, 1934	144 N. 3rd St., Brooklyn	3-story frame	1
Mar. 13, 1934	127 Edgecombe Avenue	5-story brick	2
Mar. 21, 1934	1909 2nd Avenue	5-story brick	7
			48

This serious record has aroused the public to demand action and New York fire protection authorities now have a backing of public opinion in their efforts to control a situation which has been the cause of concern for many years. Action has been taken in respect to some of the cases which present the most flagrant hazard, but the very number of old buildings involved presents a difficult problem in any program for immediate and complete elimination of these menaces to public safety.

It has long been a theory of building code and other public safety regulation that it is not reasonable to apply safety requirements retroactively to structures which when erected complied with the then existing laws. It may

be admitted that with the enactment of a new building regulation it is not reasonable to require immediate compliance with the new law on the part of every existing structure, but it seems obvious that conditions which were recognized as contrary to public safety as long ago as 1901 should not be now permitted to continue, particularly where the hazard is aggravated by the deterioration of years. It would seem entirely reasonable and consistent with the proper application of the police power when adopting any new legal requirements for fire safety to provide that the conditions which the new law is designed to eliminate should not continue more than some specified period of years — long enough to permit owners to make changes without undue hardship, but short enough to prevent the development of situations such as that now reported from New York City.

* * * * *

Cigarettes and Matches. The careless disposal of smoking materials continues as a major fire cause, in spite of all efforts to control this hazard. Unlike many fire causes which can be controlled by mechanical safeguards, the attack on the "matches—smoking" hazard has been almost wholly limited to educational measures — valuable, of course, but necessarily limited in effectiveness by the human element. Mechanical and chemical methods of controlling the hazard have been considered for many years, numerous patents have been granted for inventions in this field, and tests by the U. S. Bureau of Standards (reported in the October, 1933, QUARTERLY, p. 132) show that treatment to reduce the danger of ignition by cigarettes is entirely practicable. But no such method has been applied to any extent, for in the absence of compulsion no manufacturer seems disposed to do anything that might increase the cost or decrease the rate of burning and consumption. It is however interesting to note the development in England and Switzerland of a new and popular type of cigarette, with a "filter tip" advertized to have remarkable effects in improving the flavor and decreasing the irritation from cigarette smoke. This "filter tip" apparently has the same effect as the treatment shown by the Bureau of Standards tests to reduce greatly the frequency of ignition from discarded cigarette ends. As it is made of paper, cheaper than tobacco, there would seem to be a commercial incentive for its adoption. The match hazard is being reduced to some slight extent by the substitution of pocket lighters for matches, and among the new patents recently issued is one for a self-extinguishing match, designed to fall in such a way that the flame will be extinguished as it drops. It is perhaps Utopian to expect any complete solution of the "matches—smoking" fire problem, but these new developments at least point to the possibility of some control of the hazard not wholly dependent upon the fallible human element.

Minutes of Meeting of Board of Directors

Atlantic City, January 20, 1934.

Members Present.

Albert T. Bell, Chairman
Sumner Rhoades, President
F. T. Moses, Past President
H. L. Miner, Vice-President
Geo. W. Elliott, Vice-President
Franklin H. Wentworth, Managing Director

Eugene Arms
F. R. Bradford
C. H. Haupt
Arthur H. Kehoe
W. E. Mallalieu
S. D. McComb
C. W. Mowry
S. L. Nicholson
C. W. Pierce
D. J. Price
A. R. Small
Richard E. Vernor
Sidney J. Williams

Business Transacted.

The program of the 38th annual meeting was discussed and referred to the Program Committee.

The status of the Membership, Publications, Quarterly advertising and the Field Service activities was reported by the Executive Office.

Progress in the development of the Marine and Volunteer Firemen's Sections was reported and discussed, and the Marine Committee was authorized to set up a subcommittee on the Maintenance of Marine Terminals.

The status of the American Standards Association and the relation of the N.F.P.A. thereto were discussed by Mr. Small and Mr. Nicholson and it was voted to record the appreciation of the Board of Mr. Small's services as N.F.P.A. representative to the A.S.A. and its subscription to and approval of his sentiments and attitudes expressed at this meeting.

The report of the Committee on Technical Committee Procedure was considered and approved and it was voted to continue this committee for another year.

Technical Committee Items.

(a) Fire Pumps.

In the revision of the Regulations for the Installation and Operation of Centrifugal Fire Pumps adopted in 1933 (Proceedings, page 279) paragraph 404 (e) of the 1929 edition was accidentally omitted from the section on Gasoline Engine Driving. The committee recommended the reinsertion of this as paragraph 401 (m) as follows:

(m) Cooling water for the engine should be supplied by a circulating pump furnished with the engine, and taking its supply from the first stage of the fire pump. Where the

fire pump takes water under a lift, a second cooling water supply shall be provided, such as an auxiliary tank connected to the priming tank of the fire pump, as shown in Fig. 9, A or B.

The above action was approved.

(b) Flammable Liquids.

In accordance with authorization by the annual meeting (Proceedings 1933, page 431), the committee revised the Regulations on Oil Burning Equipments and submitted the text to the Directors for approval. On recommendation of the Committee on Technical Committee Procedure acting as the advisory agency for consideration of interim technical items, it was voted that the Regulations on Oil Burning Equipments be approved, subject to further consideration by the Committee on Flammable Liquids of details to which objection has been made, the revised regulations to be referred to the Committee on Technical Committee Procedure with power to adopt on behalf of the Directors. (Mr. Bradford voting no.)

It was further voted that the Committee on Laws and Ordinances be empowered to promulgate a model ordinance on oil burning equipment based upon the above regulations. (Mr. Bradford voting no.)

In accordance with the recommendation of the Committee on Technical Committee Procedure, no action was taken on a proposed extension of scope of the Committee on Electric Railway Car Houses and Cars.

The list of changes in technical committees and in N.F.P.A. representatives on A.S.A. committees was endorsed by the Committee on Technical Committee Procedure and approved.

The matter of proposed N.F.P.A. regulations governing bakery and other gas-fired ovens was referred to the Committee on Manufacturing Risks and Special Hazards.

The matter of the Hazards and Protection of Homes and Small Properties as presented by Mr. Powell Evans was referred to the following committee for consideration and report to the Board at its next meeting:

George W. Elliott, Chairman; H. L. Miner, F. T. Moses, C. W. Pierce, D. J. Price.

Communications from (a) the Chamber of Commerce, Elmira, N. Y., and (b) the editor of Farm Fire Prevention, Detroit, Mich., were considered and referred to the Managing Director for reply.

The report of the special committee appointed to confer with the wood shingle interests was presented by Mr. George W. Elliott and it was voted to suspend publication of the printed lists of cities prohibiting by ordinance the use of wood shingles as roof coverings, and to refer to the Committee on Building Construction for consideration the wood shingle manufacturers' suggestion that the present classification of roof coverings be revised.

U. S. Fire Losses for 1932-1933.

Compiled by National Board of Fire Underwriters.

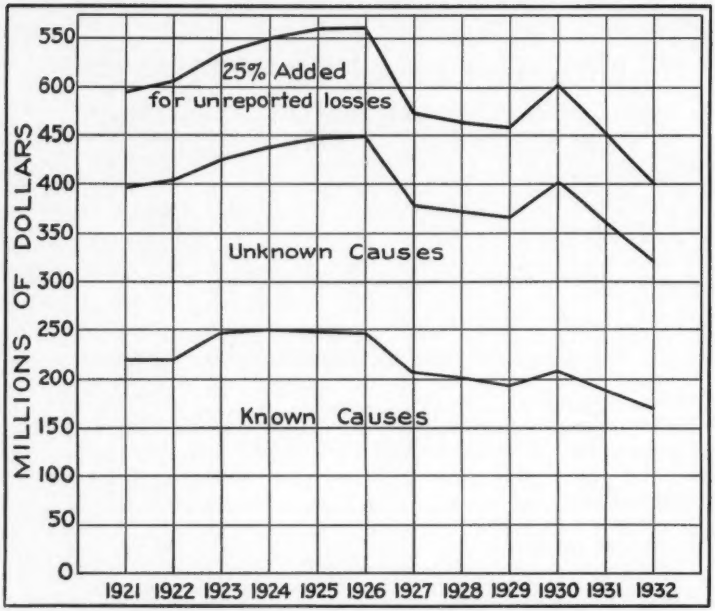
The United States fire losses for 1932 were $400,859,554, according to the final figures of the Actuarial Bureau of the National Board of Fire Underwriters published in the winter issue of *Safeguarding America Against Fire.* This figure supersedes the previous estimate of the 1932 fire loss made by the National Board as published in the July, 1933, QUARTERLY, page 19. Reference should be made to July and January QUARTERLIES for fire loss figures for 1930 and previous years.

American Fire Losses Compared, 1931-1932.†

Causes	1931	1932
Matches—Smoking	$28,174,240	$23,888,249
Defective Chimneys and Flues	20,736,837	19,761,761
Stoves, Furnaces, Boilers and Their Pipes	14,726,047	14,333,427
Electricity, Misuse of	13,667,186	11,883,154
Sparks on Roofs	11,271,709	9,452,598
Petroleum and Its Products	10,550,319	9,237,926
Spontaneous Combustion	11,055,629	9,904,940
Lightning	7,408,414	5,480,236
Hot Ashes and Coals	4,528,071	4,002,058
Open Lights	2,280,925	2,304,631
Sparks from Combustion	1,560,773	1,956,032
Sparks from Machinery	4,550,969	3,216,610
Miscellaneous Known Causes	2,169,062	2,511,731
Rubbish and Litter	1,283,290	955,216
Gas, Natural and Artificial	2,335,294	2,014,008
Incendiarism	16,664,881	17,639,122
Ignition of Hot Grease, Tar, Wax, Asphalt, etc.	1,670,899	1,400,823
Explosions	1,420,000	1,658,801
Fireworks, Firecrackers, etc.	490,779	326,206
Steam and Hot Water Pipes	244,460	45,444
*Exposure (including Conflagrations)	30,621,786	26,276,387
Unknown Cause	173,903,523	152,438,283
Total	$361,315,093	$320,687,643
25% to Cover Unreported Losses	90,328,773	80,171,911
	$451,643,866	$400,859,554

The losses for 1933 are estimated by the National Board at $316,897,733. This figure, determined since the publication of the January QUARTERLY, is approximately 0.4% less than the preliminary estimate which appeared in that issue.

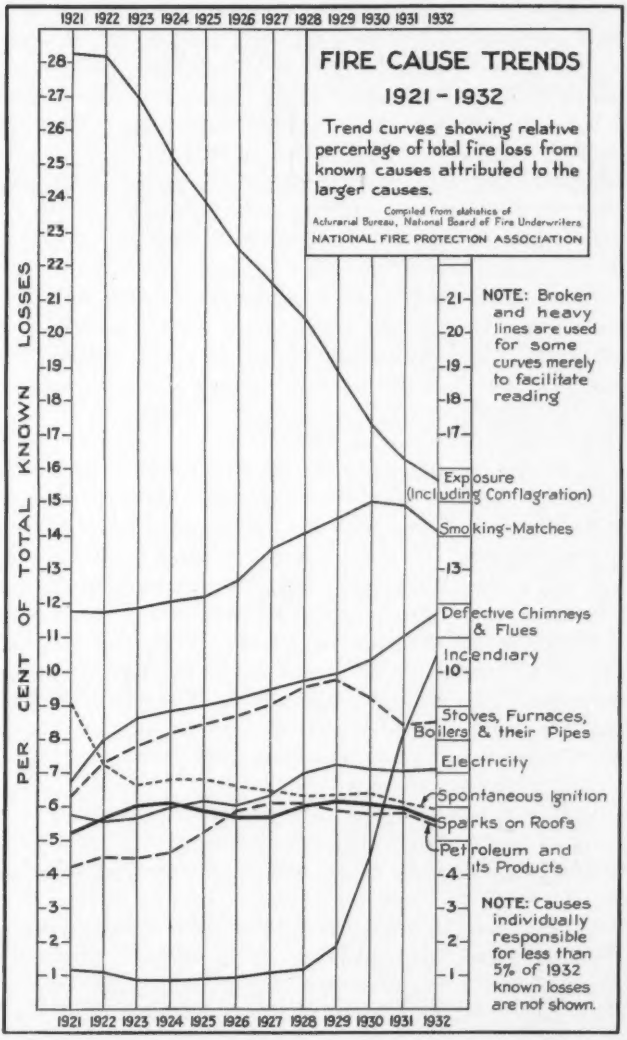
†Table of losses by states appears on page 299.
*Losses due to spreading fires originating from various causes.



The accompanying chart shows graphically the total United States fire losses for the years 1921-1932 inclusive as reported by the National Board of Fire Underwriters, plotted to show the proportion of the total losses attributed to fires of known causes, fires of unknown cause and the twenty-five per cent addition for unreported losses.

Fire Cause Trends.

Detailed figures showing the distribution of losses by causes have now been available for a sufficient length of time to make an analysis over a period of years significant. The accompanying chart of Fire Cause Trends has been compiled from the statistics of the National Board of Fire Underwriters as published in the QUARTERLY from year to year. The purpose is to analyze the relative importance of the several fire causes. This chart shows the percentage of the total loss in fires of known causes which is chargeable to each of the larger fire causes. The graphic method of presentation selected is such as to equalize the effect of fluctuations due to changing dollar values and to minimize the possible distortion of curves due to individual large loss fires. As the basic data are presented in terms of dollars of loss, rather than in numbers of fires, they may not for a single year give an accurate picture of the relative frequency of fires occurring due to the different causes, but when


FIRE CAUSE TRENDS
1921 - 1932
Trend curves showing relative percentage of total fire loss from known causes attributed to the larger causes.
Compiled from statistics of Actuarial Bureau, National Board of Fire Underwriters
NATIONAL FIRE PROTECTION ASSOCIATION
PER CENT OF TOTAL KNOWN LOSSES
1921 1922 1923 1924 1925 1926 1927 1928 1929 1930 1931 1932
NOTE: Broken and heavy lines are used for some curves merely to facilitate reading
Exposure (Including Conflagration)
Smoking-Matches
Defective Chimneys & Flues
Incendiary
Stoves, Furnaces, Boilers & their Pipes
Electricity
Spontaneous Ignition
Sparks on Roofs
Petroleum and its Products
NOTE: Causes individually responsible for less than 5% of 1932 known losses are not shown.

plotted over a twelve-year period, using a graphical method which smooths out the effect of annual fluctuations, the result is clearly significant.

The most striking feature of fire cause trend shown by this chart is the steady decline in the portion of losses chargeable to exposure, including conflagrations. This reflects a progressive increase in fire department efficiency and gradual improvement in the character of building construction, better pro-

tection against exposure fires and other factors which tend to reduce the losses due to sweeping fires.

The sharp increase during the past few years in losses due to incendiarism is likewise particularly significant. This rise presumably reflects not only the increase in incendiary losses due to the economic stress of the depression period, but also better investigation of fires and realization of the importance of the incendiary fire problem on the part of fire protection authorities. It is generally believed that incendiarism is responsible for fire losses substantially greater than the reported totals, which can include only those cases where the suspicious character of the fire is clearly established; other incendiary losses are of necessity included in the unknown classification.

It is interesting to note that some of the causes which have received consistent attention by fire protection authorities are nevertheless increasing in prominence. The curve showing fires reported as due to the misuse of electricity, for example, shows an upward trend, despite the increasing efficiency of application of the National Electrical Code during the period. This would indicate that the increase in the use of electricity has more than offset the reduction in losses from this cause that might have been expected from the more general observance of the National Electrical Code.

The curve showing fires due to sparks on roofs shows the continuing importance of this fire cause, despite the increasing replacement of wooden shingles by fire-safe roofing during the post-war period, and indicates the need for continuing the campaign for fire-safe roofing until the flammable wooden shingle roof is eliminated. In addition to fires reported as sparks on roofs many losses classified under the heading "Exposure, including Conflagrations" are due to wooden shingle roofs, and the decline in the exposure loss curve is doubtless partly due to the increasing number of cities that have adopted effective roofing ordinances.

The increase in loss due to petroleum and its products seems to be substantially less than the relative increase in the use of gasoline and oils, thus reflecting better methods in the storage and use of these essentially hazardous products.

There is no obvious explanation for the curves showing losses due to defective chimneys and flues, and due to stoves, furnaces, boilers and their pipes. A partial reason for the increase may be found in the increasing use of high-heat fuels, which impose an additional load too great for heating devices and chimneys that do not meet present standards of construction and installation.

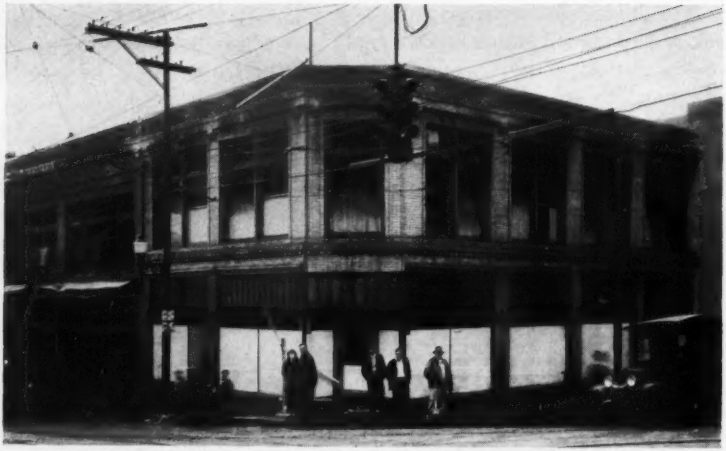
The rise in the curve of fires due to smoking—matches reflects the general experience of fire protection authorities who have found that the fire loss due to this cause follows closely the increase in smoking.

The decline in losses reported as due to spontaneous ignition is not the result of any change in this fundamental phenomenon, but is presumably due to better methods of storage and handling of material subject to spontaneous heating and also to more careful investigation of fires.

Various other fire causes individually responsible for less than five per cent of the 1932 known losses, while not shown on the chart because of space limitations, are also deserving of careful consideration. The decline of the losses chargeable to several of these smaller causes is coincident with the increase in the causes shown on the chart. Some of the less frequently reported causes are less susceptible to analysis because of the possible distortion of the curves of relative importance by a single large loss fire.

Comparison of U. S. Fire Losses, 1931-1932, by States.

State	Recorded Loss 1931	1932	State	Recorded Loss 1931	1932
Alabama	$6,782,694	$5,182,347	New Hampshire	$3,076,774	$2,306,298
Arizona	5,466,905	1,872,120	New Jersey...	15,188,425	13,103,019
Arkansas	1,082,451	4,700,919	New Mexico...	612,571	803,668
California	17,781,006	14,249,218	New York.....	46,200,677	47,022,373
Colorado	1,561,675	1,777,084	North Carolina	9,130,631	7,583,154
Connecticut ...	4,153,270	4,169,654	North Dakota.	2,775,414	1,467,249
Delaware	654,995	654,220	Ohio	16,009,787	13,549,442
Dist. Columbia	410,564	272,266	Oklahoma	6,174,770	4,497,547
Florida	4,720,253	4,384,669	Oregon	4,118,357	2,723,665
Georgia	8,781,180	6,498,346	Pennsylvania...	22,030,880	21,296,327
Idaho	1,450,770	1,090,679	Rhode Island..	2,290,725	1,752,386
Illinois	20,406,601	17,438,254	South Carolina	5,152,367	4,884,666
Indiana	6,775,245	5,874,798	South Dakota.	1,832,612	1,181,477
Iowa	5,824,617	4,543,663	Tennessee	8,721,442	7,530,422
Kansas	3,924,103	3,716,613	Texas	19,563,091	16,458,308
Kentucky	6,514,289	6,172,694	Utah	1,033,030	750,824
Louisiana	6,474,758	6,103,596	Vermont	998,489	738,733
Maine	3,743,792	3,622,493	Virginia	7,887,856	6,272,132
Maryland	3,810,500	4,727,950	Washington ...	6,914,982	5,058,076
Massachusetts..	18,543,157	19,281,425	West Virginia..	4,668,281	3,867,107
Michigan	11,317,550	9,346,293	Wisconsin	6,556,334	5,942,277
Minnesota	6,551,403	4,957,793	Wyoming	475,478	486,537
Mississippi ...	6,972,806	5,075,829			
Missouri	11,063,555	10,727,929	United States..	$361,315,093	$320,687,643
Montana	1,955,889	1,942,012	25% for Unreported Losses	90,328,773	80,171,911
Nebraska	2,922,261	2,695,573			
Nevada	255,831	333,519	Total...	$451,643,866	$400,859,554



The Federal Transient Bureau building where nineteen men were burned to death. When the inside stairs were cut off by fire the only escape from the second floor was by the windows, which were blocked by a wooden screen five feet above the floor.

Interior view showing stairway cut off early in the fire where many of the victims died. When firemen arrived flames were coming from every window. With the exception of five injured who died later, all of the fatalities occurred before the firemen arrived.

Lynchburg Transient Bureau Fire.

Nineteen men died and 67 others were injured in Lynchburg, Va., when a fire at 4:50 A.M., March 24, 1934, swept through the Federal Transient Bureau quarters for homeless men in a converted mercantile building, altogether unsuitable for use as a barracks. Factors responsible were inadequate and obstructed exit facilities, overcrowding, lack of fire drills, no inside alarm system, delay in calling the fire department due to attempt of employees to fight the fire, failure to provide a vent flue for the stove where the fire started, and omission of fire stopping at the abandoned elevator shaft over the kitchen.

The building in which the fire occurred was a two-story and basement brick-joisted structure erected about ten years ago for mercantile occupancy and divided into two sections by a fire wall with an opening on each floor protected by a fire door. There were no stairways or exits from the front section, making it necessary for men sleeping there to go through the fire door to reach the two stairways in the rear portion.

The front section, which was occupied by negroes, had originally been a show room for a store, and on two sides there were large plate glass windows which could not be opened. In order to give the men privacy these windows were boarded up to a height of four feet.

The fire started in the small basement kitchen, occupying space which was formerly the basement landing of the elevator shaft, but which had been floored over and ceiled below the floor with pine boarding. The old weight shaft to the roof was left open and acted as a flue, quickly spreading the fire to the floors above.

The fire occurred when the cook poured water into hot grease, causing it to boil over and ignite. The hood over the cooking range had been built for a smaller stove and there was no vent pipe to the outside, which would have carried off the heat. Flames flashed to the woodwork above the stove and spread through the weight shaft to the floors above. The cook and his helper used extinguishers in the kitchen and on the first floor, but could not check the fire in the shaft and were finally driven out.

Apparently the first notification the 190 sleeping men had was when some of them smelled smoke. The two stairways in the rear section were almost immediately cut off. It was while trying to escape down these stairways that many of the victims were trapped. Others could not reach the windows in the smoke and darkness. Many were injured by jumping. The first alarm was sounded by a policeman at 5:05 A.M.

This report has been prepared from data furnished by L. S. Jones (Member N.F.P.A.), Chief, Bureau of Fire Prevention, Richmond, Va., and B. Y. Calvert (Member N.F.P.A.), Lynchburg, Va.

This picture of a fire in a large manufacturing plant some years ago is typical of disasters that not only destroy buildings and contents, but the value of the business as a going concern. The progressive modern manufacturer is doing everything he can to assure the continuity of operations which protect his investment.

Fire Prevention and Modern Manufacturing.

By H. L. Miner,
(Member N.F.P.A.)

Modern manufacturing includes a multiplicity of occupancies, involves all types of construction, and presents a wide variety of fire hazards. In this article there will be discussed a few of the more interesting phases of the subject, taken from the experience of the author as indicative of the types of problems encountered.

Industry is constantly endeavoring to develop new materials or devices which will meet some need in our human experience or for which there is a demand; to improve its products and to make its processes more efficient. New processes, or changes in old processes to make them more efficient, may improve conditions or may introduce new hazards. For example, the cementing of the soles of shoes to the uppers instead of attaching by the old process of stitching or sewing them together, introduced a new hazard into the shoe industry; namely, the use of pyroxylin cement, but one which was immediately recognized and properly safeguarded, with the result that there have been few if any fires from this change.

The Fundamentals of Fire Safety.

Changes such as this will continue as the art of manufacturing advances; but the problem of applying the fundamentals of fire prevention and protection will remain the same. Let us consider what these fundamentals might be.

First, eliminate the hazard by substituting non-hazardous materials or non-hazardous operations. Sometimes this may be possible, but not often.

Second, safeguard the condition or conditions which may cause a fire or explosion. This can usually be accomplished if given sufficient thought and attention.

Third, if impractical to substitute less hazardous materials or operations, or if unable to fully safeguard the hazard, consideration should be given to proper building construction or process enclosure, the reduction of the amount of material involved to a minimum, and the provision of fire extinguishing devices to prevent excessive destruction should untoward conditions occur.

These are the fundamentals which must be given attention when considering fire prevention and protection in modern manufacturing processes, which now involve the use of high pressures, high temperatures, catalysts and

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Condensed from a paper presented at the Greater New York Safety Conference, March 6, 1934. The author, vice-president of the N.F.P.A., is manager of the Safety and Fire Protection Division of E. I. duPont de Nemours and Company.

electrical energy in processes which are now quite different from those encountered twenty-five or thirty years ago. Likewise, materials, articles, or compounds which are in our markets and stores today differ radically from those displayed or sold thirty years ago.

Whenever a new material or process appears in industry, or a new commodity in our markets, those in authority begin to speculate about the hazards which may be introduced. Often in their endeavor to "play safe," they set up restrictions that work unnecessary hardships.

Industry has a vital interest in the regulation of its products. Most of the things which cause fires through misuse, either carelessly or ignorantly, are produced by industry. The success of any industry depends upon the continued demand for its output, and manufacturers who are prudent and alert welcome reasonable regulations. Knowing the hazard of their products, they willingly coöperate with regulatory bodies drafting such measures.

The Safeguarding of a Hazardous Manufacturing Plant.

The development during the past ten years of pyroxylin lacquer finishes, of which the pioneer product has been "Duco," presents an interesting example of the successful handling of hazardous materials. The manufacturing processes required the storage, handling, and use of large quantities of a flammable material, namely, pyroxylin cotton or nitrocellulose; large quantities of volatile flammable liquids; and the combining of these materials, presenting both fire and explosion hazards unless proper conditions were set up and maintained.

After the site for the new plant for this product was selected by the duPont Company the design engineers, plant operating men, and the safety and fire protection representatives met to discuss the type of buildings, their location with reference to each other, the storage and handling of materials, installation and safeguarding of manufacturing equipment, and desirable fire prevention and fire protection measures.

The fire and explosion hazards likely to be encountered were carefully analyzed. Fire-resistive construction was decided upon for the buildings. The first plant consisted of relatively small area buildings, one to three stories in height. Later on, these units were increased in area and joined together, the different sections, however, being separated from each other by blank fire walls. The exterior wall openings were protected by wired glass in metal frames and standard fire doors. The buildings were equipped throughout with a wet system of automatic sprinklers. Wherever flammable vapors were likely to be discharged or accumulate, specially designed mechanical ventilating systems were provided. The lighting was by electricity, wires being installed in metal conduit, lights enclosed in vapor proof globes with switches and fuses located on the outside of the buildings. Later on, oil immersed

electrical control equipment was employed. Well-ventilated motor rooms, with outside entrance only, were provided.

Next, the manufacturing equipment was considered. It was agreed that as far as practicable, all equipment containing volatile flammable liquids was to be tight, with necessary vents or breather openings at safe locations outside the buildings, thereby preventing the discharge of flammable vapors where they might endanger life and property. The charging openings for filling the mixers were provided with non-sparking, tight fitting metal covers, so arranged that when open only a minimum of exposure would result. The solvents were handled through permanently installed pipe lines, and even the mixing and weighing tanks had tight connections, with outside building vents.

In the first installation, a system of open sprinklers with manual and automatic control was installed over mixers, material handling pumps, over filter presses, centrifuges, and similar equipment. This system was afterwards changed because the water damage was so extensive when the system was operated prematurely, or accidentally, or the system used for small fires which could be and were easily extinguished with first aid equipment. The system was not removed, for the sprinklers had been placed at what were believed to be danger points. The open heads were merely replaced with Quartz bulb type sprinklers and the controlling valves secured open. Customary first aid fire fighting devices and outside hydrants and hose with adequate high pressure water supplies were provided.

The question of solvent handling was a real problem. The pumping system, while recognized as perhaps the safest, was not entirely satisfactory, due to the large quantities to be handled. The compressed air method of handling was considered, but discarded as being too hazardous. This was before the advent of the inert gas systems which are now available and in use today.

It was finally decided to place the large solvent storage tanks on a high elevation and discharge by gravity through overhead pipe lines. The tanks were properly diked, protected against the sun's rays, and provided with protected vents. Shut-off valves were installed at the tanks and at the discharge points in the buildings. Additional emergency shut-off valves with remote control were installed in each tank discharge so that in the event of trouble, the discharge through broken lines could be prevented. Later on, in another plant, the pump method of handling solvents was worked out and has proven very satisfactory.

Of course, all flames, sparking devices, and as far as possible other sources of ignition were eliminated. A complete grounding system was installed, bonding together all tanks, mixers, supply and discharge lines, and even portable receptacles, to prevent the accumulation of static electricity. Smoking and the carrying of matches was absolutely prohibited.

In view of the precautions taken to eliminate or control the hazards on the plant just described, the fire and explosion record is interesting. During the past nine years, about forty-eight million gallons of lacquer and other pyroxylin finishes have been manufactured. The total fire loss during this period was $2972. No fires have been experienced from the handling of large quantities of solvents or in the packaging operations or storage. None of the fires which occurred was particularly interesting or resulted from any unusual or any unforeseen causes. The majority of them were the result of the failure of the human element, which is so difficult to control in any manufacturing establishment.

Today we are still appreciative of the inherent fire and explosion hazards in the manufacture of pyroxylin lacquer compounds and now have under consideration the installation of an inert gas system to protect the storage, mixing and weighing tanks. This will reduce the inherent fire hazards to almost the vanishing point.

Controlling the Hazard of a Spreading Process.

The following is an interesting example of measures taken to control or eliminate an acute fire and explosion hazard in a specific modern manufacturing process in a large plant.

The process involved the use of several large enclosed machines for applying a flammable coating to cloth. The coating compound contained a volatile flammable thinner. The coated cloth was passed over steam pipes to accelerate drying. For economic manufacture, it was necessary to recover the solvent vapors driven off as the material dried. Although it was obvious that there existed highly flammable and possibly explosive mixtures of vapor and air in the machines, it seemed necessary to use that particular type of apparatus. It was recognized that the moving cloth and parts of machine not only introduced friction hazards, but also static electricity, that unless the steam pipes were kept very clean they might cause fires, and that the difference between a flash fire and results similar to an explosion was the degree of confinement. In fact, several very serious fires and explosions, wrecking the machines and damaging the sections of buildings where they were installed, occurred every year for several years.

After a careful analysis of the problem, a light, easily lifting top was placed on the machines to relieve the pressure should the vapors be ignited when within the explosive range. Similar vents were provided in the building structure immediately over the machines. The steam pipes were thoroughly guarded and insulated. Automatic sprinklers were installed over, under, and inside the machines. Scrupulous housekeeping was maintained. All parts of the machines were bonded together with heavy gauge bare copper wire. Dragging contacts were installed on rollers and the dry cloth as it issued

from the machines, and the whole bonding system was grounded. Humidification was employed at certain locations to help prevent and dispel static charges. And lastly, before the machines were operated after a shut-down period, solvent was vaporized in the machine to quickly produce a solvent vapor-air condition far too rich to ignite, thereby reducing to a minimum the interval when the solvent vapor and air mixture would be explosive. Carrying of matches, smoking, or using flame or spark producing devices was absolutely prohibited. After these precautions were taken only a few quite minor fires were experienced until one morning an operator noticed a loose ground connection at the coating end of one of the machines. Before the condition could be remedied, a serious explosion occurred in the machine, doing considerable damage and injuring several employees.

This experience indicated that despite all the precautions taken, an acute inherent fire and explosion hazard existed in these machines, and that the failure of any one of a number of safeguards or the human element might result disastrously. With the advent of the activated carbon recovery system for recovering solvent vapors, the entire situation changed. Now, instead of operating with a rich or explosive mixture of solvent vapor and air in the coating machines, the solvent vapors are diluted, as given off, far below the lower limits of the explosive range. During the past five or more years since this type of recovery system has been used, not even a suspicion of a fire or explosion involving flammable process vapors has been noted. Even so, the precautions of grounding, housekeeping, fire extinguishing, etc., have been maintained. If the fire and explosion hazard, as the process is now conducted, were at all serious, inert gas could be substituted for air to eliminate all fire and explosion possibilities, but such steps are not considered necessary at the present time.

Fire Prevention and Fire Extinguishment.

Twenty-five or thirty years ago, more attention was given to fire extinguishment than to the prevention of fire. Prevention should be primary and extinguishment, while tremendously important, secondary.

Automatic sprinkler systems, first developed for the protection of textile mills, are now used for the protection of all classes of occupancy — even in buildings used for the manufacture of high explosives. Fifteen years ago, no explosive manufacturer would consider installing automatic sprinklers in a dynamite box packing house; that is, where the dynamite already packed into cartridges is dipped in melted paraffin and then boxed for shipment. After several disastrous explosions in buildings of this occupancy, a careful study showed the fires which were causing the explosions started in or around the paraffin melting kettle; and that the time interval before the explosives in the building were ignited was of sufficient duration to allow automatic

sprinklers to operate and probably control or extinguish the fire. The thought of installing an overhead piping system in an explosive building, considering the increased missile hazard should an explosion occur, caused a great deal of discussion. Special rubber hose with brass or bronze fittings supported in wooden troughs was considered; but finally ordinary metal pipe automatic sprinkler systems were installed. On several occasions since their installation, these systems have successfully extinguished the fire and saved many times their installation cost. Now automatic sprinklers originally designed to control fires in textile mills are protecting all types of manufacturing establishments, mercantiles, schools, hospitals, penitentiaries, churches, art museums, and even residences.

We all remember the introduction of the foam extinguishing systems and their effectiveness in controlling fires in oils and similar materials. Following this came the use of inert gas, first carbon dioxide and nitrogen from bottles, and then the inert gas system supplied by gas generators.

Some of the recent inert gas applications with which I am familiar and which are indicative of the future, may be of interest.

In one process where large quantities of metallic sodium are used, the process is conducted in an atmosphere of nitrogen.

In an ethyl alcohol plant, carbon dioxide from the fermentation vats is collected and discharged into equipment to exclude the oxygen and prevent fires and explosions. One of the units protected, I am told, is a 55,000 barrel storage tank containing 2,750,000 gallons of alcohol.

Recently a disastrous dust explosion occurred in apparatus grinding and conveying a synthetic gum. The inherent explosion hazard was recognized. The equipment was made tight, and an inert gas generating machine installed. Now the process is carried on under inert gas protection, eliminating all possibility of fire and explosion.

In another process, it was necessary to carry on certain operations at a very high temperature. The reactions gave off a flammable gas which sometimes ignited and set fire to the material in process. This operation is now safely carried on under inert gas protection.

Fire Safety Measures Based on Unbiased Study.

Whether considering the protection of new processes or the adequacy of safeguards already provided, the problem must be attacked with an open, unbiased mind, regardless of tradition, preconceived notions, prejudices, or personal feelings. Ascertain the facts and be guided accordingly.

For example, some time ago, a controversy started because automatic sprinklers were recommended over several large dip tanks, each containing 2500 gallons of an oil base enamel or paint. Based on past experience, the insurance underwriter could only visualize a flash fire opening a large number

of sprinklers and the water overflowing the tanks, carrying the burning paint or enamel to other parts of the factory. An investigation showed that the paint or enamel was four pounds heavier per gallon than water. Consequently, should fire occur, the water would not only extinguish the fire, but seal over the dip tanks and prevent reignition.

Conversely, carbon dioxide should not be used with the thought of preventing or extinguishing a fire in aluminum dust. Aluminum dust has a very wide explosive range, burns with great intensity, and is very eager to unite with oxygen. In fact, its affinity for oxygen is so great that when glowing or burning, it will break down carbon dioxide, releasing the carbon and uniting with the oxygen with almost explosive force. Recent tests, however, indicate that inert gas composed of 87% nitrogen and 13% CO_2 will reduce the flash or fire possibility to a minimum.

Protection to Assure Continuous Operation.

An executive of a large corporation realized that practically the entire output of his plant depended upon the ability of certain other manufacturing plants to supply essential parts or materials used in his product. He inquired whether or not these plants were sufficiently immune from a disastrous fire to insure that they would always be in a position to furnish the desired materials. This brought about a very careful survey of the supply plants in question and it was found that while they were entirely acceptable to the insurer, from a probable loss standpoint, the expenditures necessary to protect operations sufficiently to guarantee against a disastrous fire which might curtail plant operations involved expenditures of some three hundred thousand dollars on one plant; four hundred thousand dollars on the second plant; and some three hundred and fifty thousand dollars on the third plant.

This shows a growing tendency on the part of the up-to-date manufacturer to view his problem from the broader aspect; within economic limits, he is doing everything he can to insure the continuity of operations which protect his investment.

Molasses Tank Explosions.

By C. A. Browne,
Bureau of Chemistry and Soils, U. S. Department of Agriculture.

Recent reports in the German sugar journals of the explosion of a molasses tank at a beet sugar factory bring up again the question of the causes of such accidents and the means for their prevention. Fortunately these catastrophes are of rare occurrence, although they may approach the magnitude of a great disaster as happened in the famous collapse of a molasses tank in Boston on January 15, 1919, when twelve persons were killed, forty injured and vast damage was done to surrounding property.

The recent explosion reported in the German journals took place in a molasses tank at a beet sugar factory in Silesia on November 18, 1932. The tank was of the ordinary cylindrical construction 39 feet, 4 inches in diameter and 25 feet, 7 inches high, and consisted of well-riveted sheet iron plates 11/32 inch thick upon the sides and 15/32 inch thick upon the bottom. The tank rested upon a foundation of concrete pillars with a circular concrete wall underneath the outer edge. The tank had a capacity of 233,000 gallons and contained approximately 1324 tons of beet molasses at the time of the accident. The tank had been in use since 1895 and had not been cleaned in 15 years. The explosion took place about 3:30 P.M. with a dull report, a section of the side near the bottom being blown out and a part of the molasses ejected to a distance of 40 feet. Through this opening the rest of the molasses in the tank flowed slowly out upon the ground. The force of the explosion caused windows to rattle at a distance of 328 feet and dislodged a block of lead weighing several pounds in a work shop 82 feet distant. The molasses tank was moved about four inches from its base into a slightly inclined position, the sheet iron floor of 15/32-inch thickness being deformed and bent downwards by the force of the explosion. No lives were lost.

All of the experts who investigated the accident were convinced that it was an explosion and not a collapse.

Dr. H. Freese, chemical expert of Hanover, found the sheet iron bottom of the tank to be strongly corroded over an area of about 60 square feet. He supposes that acids of fermenting molasses, such as lactic, acetic, butyric, etc., may have attacked the iron with evolution of hydrogen. The evolved gas could not penetrate the heavy viscous mass of molasses above it and because of the excessive pressure finally forced an opening through the corroded wall. The sudden release of the pressure caused air to penetrate from the outside

Paper presented before Sugar Division, American Chemical Society meeting, St. Petersburg, Florida, March 28, 1934.

and the friction of the explosive mixture of gases against the edge of the aperture produced an elevation of temperature which, with the catalytic action of finely divided iron oxide, caused the ignition and explosion within the tank which blew out the weakened plates. The explosion took place entirely at the bottom of the tank, there being no ejection of molasses from the upper surface against the roof. Dr. Freese reports finding upon the bottom of the tank tough gum-like masses of a sugary character, which could be detached from the sheet metal only by the aid of heavy implements.

With regard to Dr. Freese's suggestion as to the possible cause of the accident there are several points which appear rather dubious. First, the plates, or joints of a heavy molasses tank, which are so badly corroded as to permit the venting of gas, would be so weakened structurally that it would seem wholly unnecessary to postulate the detonation of an explosive mixture of gases as the cause of the accident. In the second place it is difficult to understand how it can happen when hydrogen is being forced through a narrow aperture with sufficient pressure to cause its ignition that atmospheric air can simultaneously be drawn into the tank—an explanation which is possible only upon the supposition that the enclosed gases of the tank can be above and below atmospheric pressure at the same time.

Dr. Spengler of the Berlin Institute for the Sugar Industry made a chemical examination of molasses from the injured tank and found invert sugar* to be present, although the reaction was alkaline. He believed the lower part of the tank to have contained strongly inverted molasses, which by the force of the explosion was afterwards mixed with the supernatant alkaline molasses. The following translation is made of a part of his report:

> That the tank collapsed owing to the pressure of the contained molasses should be definitely excluded from consideration. First, because of the strong explosion that was heard by several witnesses; secondly, because a microscopic examination of a sample of molasses, taken from the walls of the tank in the immediate neighborhood of the explosion, showed that in addition to the paint, with which the tank was protected, there could be recognized slight quantities of sand and small particles whose appearance indicated the presence of carbon, which could only have been formed by a flame shooting out from the place of fracture. Further chemical investigation of the residue showed in addition to silicic acid the presence of small carbon particles. From this the conclusion may be drawn that an explosion occurred with the production of flame: the projecting jet of flame might then have had a carbonizing action upon the organic constituents on the exterior of the tank. An explanation of the origin of the explosion presents very great difficulties. Evidently by the keeping of molasses residues many years in the same tank an inversion took place and then the invert sugar thus produced was gradually decomposed by the activity of bacteria. As a matter of fact a number of bacteria are known which can develop a slight although perceptible vital activity in highly concentrated sugar solutions.

*"Inversion" is the decomposition of cane sugar into its component sugars, dextrose and levulose, the mixture of which is called "invert sugar."

The decomposition products, probably hydrogen or methane, may have gradually produced a strong pressure and because of the superincumbent thick incrustations of sugar have had no opportunity of escaping. In view of the explosion in Boston already referred to, it may be said without question that an explosion took place with the accompaniment of fire.

The Boston Catastrophe.

With regard to the Boston catastrophe of January 15, 1919, which Dr. Spengler terms an explosion, it should be stated that many engineering experts who investigated this disaster pronounced it a collapse and not an explosion. (See report of C. E. Worthington, *Safety Enginering*, January 1919.) The Boston tank was 90 feet in diameter and 50 feet high, the depth of the molasses being 48 feet, 10 in. The estimated quantity of molasses in the container at the time of the accident was over 2,000,000 gallons or approximately 12,000 tons, which is ten times the quantity in the tank of the Silesian beet sugar factory. The Boston container, having nearly twice the height of the Silesian tank, was subjected to vastly greater pressures.

Chief Justice Bolster of the Municipal Court of Boston in his report of the inquest of the disaster (QUARTERLY, April 1919, Vol. 12, No. 4, pp. 372-3) made the following statement:

> My conclusion from all this evidence is that this tank was wholly insufficient in point of structural strength to handle its load, insufficient to meet either legal or engineering requirements. I am satisfied that the adequate and predominating cause of this accident was a bursting from internal pressure exceeding its structural strength and I so find.

In the same connection (*loc. cit.*, p. 373) Mr. Charles W. Haskell of the Great Western Sugar Company made the following comments:

> The tank was evidently only figured on a water basis of 62½ lbs. per cubic foot of contents, instead of 90 lbs. per cubic foot per weight of molasses. The plates making up the tank are heavy enough for the lighter loading only, with practically no factor of safety.

Mr. Harry E. Lake, Engineer of the Massachusetts Fire Prevention Commission, also stated in his report for January 15, 1919:

> I am of the opinion that the rupture started at or near the weak patch plate or connection and the failure threw sufficient tension into the overstressed plates to cause the complete failure of the tank, and that the failure was due to the structural defects of the tank.

Mr. Burtis S. Brown, Consulting Engineer of Boston, reported (*Engineering News-Record*, Vol. 82, pp. 974-6) that an examination of the wreckage of the molasses tank showed "that part of the vertical joints failed by shearing off the rivets, while at other points the plates were torn apart between rivets." Mr. Brown's calculations indicated that the rivets in the vertical joints of the tank near the base were overstressed 2.2 times in shear and 1.92 times in bearing.

The owners of the Boston tank, in the trial of some hundred damage suits that were brought against them, contended that the collapse of the structure was due to the explosion of a bomb placed in the tank by discontented

workmen. In support of this theory the company which owned the tank produced a witness who testified that she saw smoke ascending from the ventilator in the roof of the tank just before it gave way and this smoke was attributed by the defense to a burning fuse. Engineering experts for the company testified "that the tank was structurally safe, although the factor of safety was materially less than they would have provided." (*Engineering News-Record,* October 7, 1920, pp. 691-2.)

Reports of flame or fire in the case of the Boston accident are wholly lacking. The evidence of flame in the case of the Silesian disaster seems to be based largely upon the presence of the carbon particles, which according to Dr. Spengler "could only have been formed by a flame shooting out from the place of fracture."

Without disputing the conclusions of the German experts I would like to call attention to the fact that black granular insoluble carbon-like particles are sometimes found in deposits at the bottom of molasses tanks in which the contents have undergone spontaneous decomposition over long periods of time. Reference to the formation of such deposits is found in the writer's paper upon the "Spontaneous Decomposition of Sugar-Cane Molasses" (*Ind. Eng. Chem.*, Vol. 21, 1929, p. 600). This apparent carbonization is due to the progressive dehydroxylation of the sugar molecules; it proceeds slowly at ordinary temperature and more rapidly when the molasses is warm. In the so-called "hot room" or "froth" fermentation of molasses, the decomposition may proceed violently with copious gas production and evolution of so much heat that there may be a partial carbonization of the material. If a sudden decomposition of this character should take place in a large tank, as seems to me wholly possible with badly decomposed molasses, the rapid evolution of carbon dioxide and other gases at the bottom of the heavy viscous mass might easily generate sufficient pressure to burst the plates of a weakened structure. In this connection it might be noted that the spontaneous chemical decomposition of canned molasses and sirups has been known to cause a bulging and bursting of the tin container with considerable violence. The gas in such instances is carbon dioxide. This type of bulging is not to be confused with the so-called "hydrogen swells," where hydrogen is produced by the action of vegetable acids upon the inner metal surface of the can.

The relationship of spontaneous decomposition to gas production in tanks of molasses has been discussed by the writer in the article previously mentioned. Additional information upon this question has since been imparted to the author by sugar technologists in Egypt, who report the spontaneous break-down of cane molasses, stored in open earth reservoirs, into a porous carbonaceous mass resembling charcoal.

In the writer's opinion the printed reports regarding the accident to the molasses tank in Silesia do not present sufficient evidence to justify the con-

clusion that the rupture of the plates of the tank was due to a detonation of explosive gases. The age of the tank and the long period of 15 years in which it had not been cleaned indicate the probability not only of structural deterioration and weakening of the walls of the tank, but of the presence of very old molasses in an advanced state of decomposition, which might produce sufficient extra pressure by the rapid evolution of gas to rupture a plate at the weakest point without detonation and the production of flame.

Because of structural deterioration or defects it seems highly probable in the case of both the Boston and Silesian tanks that there was only a slight margin of safety and that only a small excess of pressure beyond that exerted by the molasses of the containers was needed to cause a disruption at the weakest part of the two structures. Excluding the possibility of sabotage, which seems unlikely since both accidents occurred in the daytime, when conditions would be most unfavorable for committing such acts without detection, the excess pressure, which caused the bursting of the tanks, was probably due, in the writer's opinion, to a strong evolution of gas, not necessarily explosive, from spontaneously decomposing molasses.

The Lightning Hazard.

Another phase of the molasses tank problem relates to the explosions which are produced when these receptacles are struck by lightning. On July 1, 1933, an all steel gas-tight roof tank 43 feet in diameter and 30 feet high, containing 69,000 gallons of molasses (approximately 400 tons) at the bulk plant of the Texas Company at Elizabeth, N. J., was struck by lightning and immediately caught fire. About ten minutes later an adjoining tank of the same size containing 8000 gallons (about 48 tons) of molasses exploded and caught fire. The fire was under control within 30 minutes. The property loss, as a result of destruction of the tanks, was approximately $10,000.

The two tanks were installed on wood pile and reinforced concrete slab foundations and each tank was connected to underground lines, so there is good reason to believe that the tanks were adequately grounded. The tanks were about 12½ years old and the molasses had been stored in them over a period of about six months. It is believed that two years previously the tanks had been used for storing gasoline. The tanks after such service, however, had been cleaned, then had remained idle for about two years and then were again cleaned before being put in molasses storage service. The possibility of explosion from residual vapors of gasoline in the tanks would, therefore, seem to be definitely excluded.

Each roof of the two storage tanks was provided with five relief valves, so there would seem to have been ample provision against the disruption of the tanks by the pressure of enclosed gases beneath the gas tight roof. If flammable gases, such as hydrogen or methane, were evolved from the

molasses as a result of fermentation or other cause and an explosive mixture of such gases was formed with the air enclosed beneath the roof, it could easily happen that a flash of lightning or the flames from an adjoining conflagration might cause a fire or explosion.

Molasses itself is not easily flammable and its ignition by lightning would not seem to be easy if the tank in which it is stored is well grounded. If the tank, however, is insulated from the ground a bolt of lightning might have a powerful decomposing action upon the molasses with production of combustible gases and other volatile products. When ignition has once started hot molasses will foam up and form a porous carbonaceous mass that will easily burn. The effect of intense heat upon the combustibility of molasses was illustrated by a recent destructive fire at Westwego, La., where a tank containing one million gallons of alcohol was ignited by lightning on June 24, 1933, the heat of the conflagration setting fire to several adjacent tanks of molasses. (QUARTERLY, October 1933, pp. 145-150.)

A review of the various accidents which have occurred in the storage of molasses indicates first, the need of careful engineering supervision in drawing up the specifications for molasses tanks so that there will be a large margin of structural safety, secondly, the need of adequate grounding of the tanks to secure protection against lightning and of adequate venting of the gases which may accumulate above the molasses, and third, the need of frequent inspection of the interior of the tanks, so that the progress of corrosion can be checked and the accumulation of molasses decomposition products prevented.

Anderson Store and Telephone Exchange Fire.

On January 29, 1934, a fire occurred in Anderson, Ind., which severely damaged the Citizens Bank Building, a so-called fireproof structure, and gutted the telephone exchange located on the fifth floor. A two-story mercantile block at the rear was also totally destroyed. The fire originated in a department store on the first floor, extended upward through an open light court and unprotected windows to offices and the telephone exchange in the upper stories, and swept across a narrow alley at the rear to the adjoining brick-joisted mercantile block.

Construction and Occupancy.

The Citizens Bank Building, erected in 1906, is typical of earlier types of fire-resistive construction, having more combustible wooden interior trim than is generally found in similar structures of more recent date. The building is six stories in height with basement, brick outside walls and interior structural steel frame supporting floors and roof. Structural steel members are protected by hollow tile metal lath and plaster. The floors are of concrete, wood surfaced throughout. The roof is of concrete. The walls of the interior light court were of tile.

The basement and grade floor formed a single large area, except that the lobby in front of the building, containing the elevator and stairs to upper floor, is cut off by hollow tile partitions. The elevator shaft and stairs above the first floor are not cut off. The upper floors are subdivided into numerous offices by tile partitions having wooden doors and trim. All window frames and sash are wooden with ordinary glass. A large open light well or court extends from the first floor upward in the center of the building, with unprotected window openings at each floor. This court was roofed over at the first floor with three large skylights. These skylights had wired glass tops, but sides were of ordinary glass.

The Fair Store occupied about one-half of the basement and the entire first floor. Offices and small shops occupied the upper floors. The exchange and operating rooms of the Indiana Bell Telephone Co. were on the fifth and sixth floors, and the broadcasting station WHBU shared the latter floor with the telephone company.

The "East Block" across the alley at the rear was a two-story ordinary brick-joisted structure with exposed windows. It was occupied by various mercantile establishments.

This report has been compiled from data furnished by the Indiana Inspection Bureau (Member N.F.P.A.), Mr. Joseph G. Hubbell (Member N.F.P.A.) and Mr. R. D. MacDaniel (Member N.F.P.A.) Photographs from Alfred Turner's Studio, Anderson.

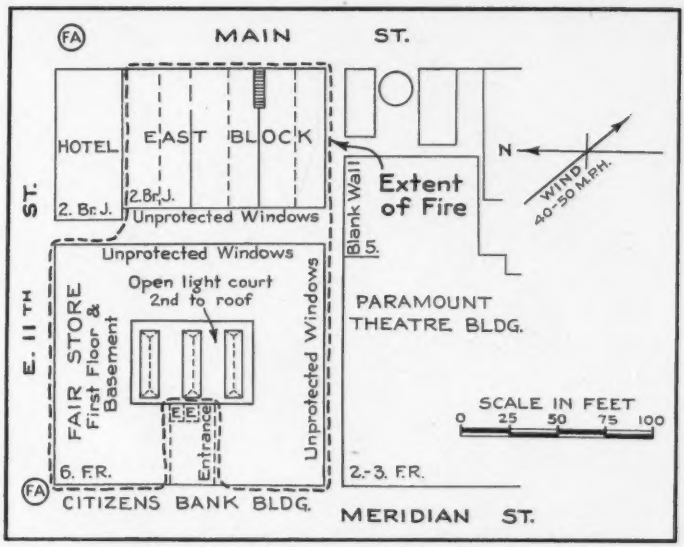


Diagram of the Anderson, Ind., fire of Jan. 29, 1934.

Public fire protection is considered good. The building is located in the principal mercantile district with a sufficient number of hydrants advantageously located and with adequate water supply. There was a city fire alarm box on the corner immediately adjacent to the building, and fire department headquarters was about three blocks distant.

There were two standpipes in the building, fed by a single 6-inch branch from a city main. Outlets with 50 feet of hose attached were provided on each floor. A part of this system that was not directly in the fire was of value to the fire department in extinguishing smouldering débris in various offices in the building after the fire was under control.

Events Preceding the Fire.

On Saturday night previous to the fire the Fair Store was closed at about 11 P.M. The only person known to have entered this part of the building between this time and the discovery of the fire on Monday morning was the elevator operator, who entered the store to turn out certain lights. The store was equipped with a burglar alarm system and it was necessary for the elevator operator to call the central office before entering. The records show that he entered at 9:02 P.M. and left at 9:08 P.M. Sunday night, or about four hours before the fire.

As the upper floors of the building were occupied by professional offices and the telephone exchange, there was more or less traffic in that part of the

The "fireproof" Citizens Bank Building, Anderson, Ind., after the fire of Jan. 29, 1934, looking southeast at the corner of Meridian and East 11th Sts. Fire started in the Fair Store on the first floor and spread up open light court to telephone exchange on top floors.

building during the day and evening preceding the fire. The only persons known to have been in the building at the time of the first fire alarm were two telephone operators on the fifth floor and the night elevator operator.

Story of the Fire.

The fire started on the first floor in the Fair Store, from which a burglar alarm signal was received at the central station office at 1:09 A.M. on Monday, January 29. The police station was at once notified. It is supposed that this signal was caused by the fusing of the wires due to the heat of the fire, for at about the same time the elevator operator observed the reflection of flames in the windows of the store across the street. He rushed out and found that the awning over one of the first floor windows of his own building was on fire and the glass breaking. He immediately notified the fire department, which call was received at 1:11 A.M. and was answered by the chief, assistant chief, three 1000-gallon pumpers and two ladder trucks. The fire apparatus and police car arrived simultaneously.

When the fire department reached the scene the entire first floor was in flames and an additional pumper was summoned at 1:12 A.M. The chief and

The Citizens Bank Building, looking west from Main St., with ruins of two-story "East Block" in the foreground.

the elevator operator went to the second floor, from which point the chief noted that flames were issuing through one of the skylights in the light well and threatening the exposed windows of the floors above. A hose line was taken to the second floor to cover this court. The chief then went to the upper floors and finding that all occupants had left the building, returned to the street to direct fire fighting operations.

A third alarm was sounded at 1:15 A.M., bringing another pumper, and a reserve pumper was put into service at headquarters. The night telephone operators went to the Western Union telegraph office and called the Muncie fire department at 1:17 A.M., which responded with a pumper and crew. A crew of men, but no apparatus, also responded from Elwood, remaining until 11:00 A.M. The Muncie Company was stationed at headquarters until about 5:30 P.M., covering the city, and responded to four fires. The fire was under control at 8:00 A.M., at which time some of the apparatus was withdrawn. Nine hose lines were laid from five pumpers to the building and in addition two pumpers had lines siamesed to the turret nozzle on the service truck and to the ladder pipe on the aerial truck. The chief attached great importance to the water curtain supplied by the turret nozzle and ladder pipe stationed at each end of the alley between the fire and the Paramount Theatre Building on the south, in protecting the latter building. One stream was also directed from the roof of the Theatre Building.

Weather conditions handicapped the firemen. The temperature was about six degrees below zero, and a 40-mile wind was blowing from the northwest. Broken store windows permitted the draft to create an intense fire and drive it to the southeast corner of the building, from whence it spread across

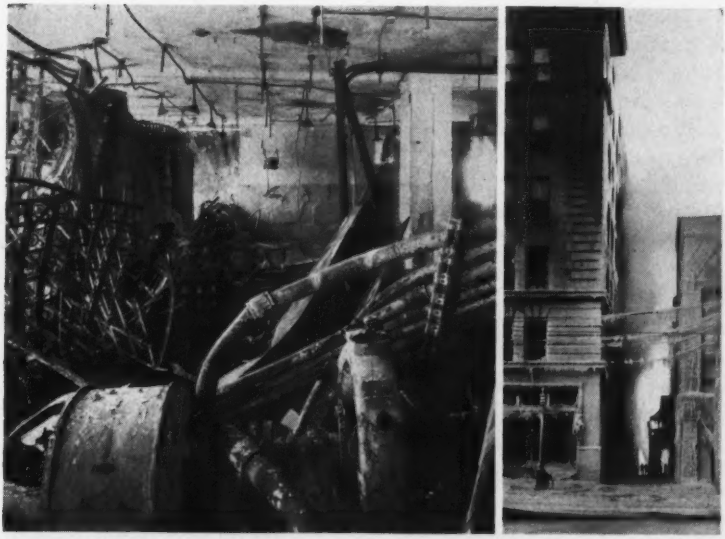
Interior of telephone exchange, showing complete destruction of equipment. Telephone service was completely restored two weeks after the fire, through the installation of new exchange equipment in another building.

the alley to the East Block, which was quickly gutted. This alley was very narrow and contained power wires and telephone cables on poles. This condition, with the intensity of the fire in this direction, made it impossible for firemen to do any close and effective work on this side of the building.

Meanwhile, fed by the highly combustible contents of the department store, the fire broke through the skylights at the first floor ceiling level of the light court, solid flame shooting upward to the upper floors. The unprotected window openings on the floors above and the difficulty of fighting the fire at this point were responsible for its rapid spread. The main stairs and elevator shaft were in the unburned part of the structure, and the single stairway in the burned area was cut off from floor to floor, so was not a factor in the upward spread of the fire. There was apparently no reverse spread of the fire from the adjoining exposure.

The Telephone Exchange.

Approximately one half of the offices in the upper part of the building were burned out or severely damaged and the telephone exchange on the fifth and sixth floors was completely gutted. The fire obviously entered the exchange from the light well and swept everything in its path.



Left: Another view of telephone exchange, showing wreckage of equipment and damage to interior finish. Right: Looking down the alley between the burning building and the theatre at the right. A water curtain from large-stream fire department appliances at both ends of this alley protected the exposed theatre.

The destruction of the telephone exchange, which served some 5500 telephone subscribers, resulted in the complete paralysis of communication in the city and with the outside. Entirely new equipment had to be obtained from the factory before complete service could be re-established in a new location.

Nevertheless, a temporary long distance connection was in service by 6:30 A.M. the day of the fire and by night twenty-three long distance circuits were available. Emergency local service was established the next day. On February 12, fourteen days after the fire, telephone service on a permanent basis was re-established in the community. As far as is known, this is a record installation for a central office of such size.

The value of an adequate and reliable municipal fire alarm system was clearly demonstrated. The system operated without any failure during the period of suspension of the telephone service. From January 30 to February 14 inclusive forty-five box alarms were received, about fifty per cent of which would normally have been telephone alarms.

Cause and Loss.

The cause of the fire has not been determined, but it is thought to have started in the vicinity of the janitor's room on the first floor in the Fair Store. It had obviously been burning for some time prior to discovery.

The extent of the damage to the building of origin has been estimated in the vicinity of 30 to 40 per cent. One point of interest was the manner in which the building withstood the fire, considering the deficient protection of the steel supporting members. The tile protection of the columns remained intact, while the metal lath and plaster ceiling gave way in only two small sections on the fifth and sixth floors in the southeast corner. The wood wearing floors were destroyed in only the east and south sections. The contents of the Fair Store on the first floor were practically totally destroyed, and while there was little if any damage to store in the basement the water damage was considerable.

In the upper floors of the building the contents of about half the offices were totally destroyed or damaged, no small item when the expensive equipment of many of the doctors' and dentists' offices is considered. The loss to telephone equipment was total (in excess of $200,000) as was the loss to radio station WHBU on the top floor.

No information is available as to the losses resulting from the destruction of records in the various offices, but it is believed that there were many office records destroyed that represented very substantial values. Likewise there is no estimate available as to the indirect losses due to interruption of business.

The destruction of the East Block, containing a number of stores and a lodging house, was complete and there was little or no salvage therein. The Paramount Theatre adjoining the bank building on the south, saved from destruction by a blank wall and a water curtain laid down by the fire department, was slightly damaged by fire and water.

Exact loss figures are not available, but the latest estimates indicate the total loss to be between $650,000 and $750,000, exclusive of losses of records and interruption to business.

Measuring Forest Fire Danger.

By H. T. Gisborne,
Northern Rocky Mountain Forest and Range Experiment Station.

The "definite need for some established unit of measurement of size of fire" is pointed out in an editorial in the October 1933 QUARTERLY. It is unfortunate that the decidedly fundamental importance of such a measurement is so seldom appreciated. The recognition, when it comes, however, is definite proof that the process or method is developing from the empirical and rule of thumb procedure, to the more exact control that distinguishes the scientific method.

In forest fire control the areal unit was for many years tacitly accepted for describing the size of a fire. Experienced fire fighters know, however, that area burned, like the value of a building destroyed, is the aftermath of the fire, and not the important factor with which they have to contend in the labor of suppression. During recent years perimeter of the forest fire has been used more and more as the best single index of size, and there is now general agreement that uncontrolled perimeter is the best indicator of the work to be done before the fire is controlled. When perimeter is converted into man-hours of labor, using the best available knowledge of timber and fuel types, resistance to held-line* construction, etc., the size of fire is then expressed in the most significant and usable terms, i.e., work to be done to suppress the fire. It might be that the size of other fires, such as burning buildings, could likewise be expressed in terms of gallons of water per minute or standard hose streams necessary for suppression, when applied at specific intervals after origin. Such an expression might convey the desired impression of size and character of fire so that all fire experts would obtain the same mental picture from the description of a particular fire.

In forest fire control there has been a great need for another measurement almost equally difficult to make. In forest protection the fluctuating condition called fire danger determines the number of men that must be on duty, the distribution of these men throughout the forest property, the area that probably will be burned, and the damages and expenses. Fire danger, however, is a general term used to designate the combined effects of several

*"Held line" is that portion of a lane, trench, or fire line which is successful in serving the purpose of stopping the spread of fire. If the fire crosses a trench or line, then that line did not hold, and is not rated as "held line." Resistance to the construction of such line varies of course with the geology, soil, topography, timber, and fuel types. When the line has to be built through a dense tangle of wind thrown trees of large diameter on steep rocky slopes, the resistance to line construction is great. On level land, of soft soil, bearing only a thin stand of weeds the fire line often may be plowed easily and rapidly. The resistance to construction of line under such conditions is rated as low.

factors. Season of the year, the activity of lightning and man as causative agencies, the visibility distance or ease with which the lookouts can discover fires, the dryness of the fuels, and wind velocity are some of the more important of these factors. When all of these factors are unfavorable then fire danger is great; when all of them are favorable there is no forest fire danger.

The problem of rating the combined effects of all of these conditions was for many years complicated by lack of measurement of some of the individual factors. For many years, in fact, no one recognized the existence of such a problem, because the experienced forest officer was supposed to be able to merely look at his forest property and thereupon to "size up" the situation and to report the status of fire danger with sufficient accuracy. When forest fire research was first commenced by the Forest Service in about 1915, there was no method available, for example, to determine quickly the dryness of the dead branchwood scattered about on the forest floor, nor the moisture content of the dead needles and twigs, called the duff, which forms a compact carpet covering the soil under all dense timber canopies. Naturally the dryness of this dead wood and duff affects the ease of ignition, the degree of flammability, the rate of spread of fire, and therefore the degree of danger.

In 1923, however, an instrument called a duff hygrometer was invented by members of the Forest Products Laboratory at Madison, Wisconsin, and after field tests and suggestions by the Northern Rocky Mountain Forest Experiment Station this device was perfected sufficiently to serve its purpose quite well. Twenty-four of these instruments are now used throughout the Northern Rocky Mountain region, and by simply reading the gauge a forest ranger is now able to determine the duff moisture content and flammability with an accuracy far greater than the estimate of even the most experienced man. Naturally this also permits more accurate, more understandable, and more useful reports. Whereas before the invention of the duff hygrometer three different rangers might report their duff as "dry," "very dry," or "darned dry," these men now report 10%, 8%, and 6%, or similarly precise figures.

A different method, employing samples of dead branchwood one-half inch, one inch, and two inches in diameter, was then developed by fire research for measuring the moisture content, hence flammability, of this common fuel which carries fire so rapidly through a forest. This so-called "wood cylinder method" is now used at 38 forest stations throughout the Northern Rocky Mountain region, and gives additional accurate measurements and reports to supplement those obtained with duff hygrometers.

During recent years more and more measurements have also been made available for some of the other factors of fire danger, such as relative humidity and wind velocity. Forecasts of lightning storms have been made more dependable, and the fire lookouts at their mountain top stations have been

trained to record and report the characteristics of every lightning storm from the time it first appears on the horizon until it disappears from view. Consequently the problem of measuring fire danger has gradually developed into one of integrating the effects of the several individual factors.

In studying the various possibilities for rating the combined effects of several conditions, each of which affected fire danger, alinement charts, slide rules, and such devices were considered. The present choice resembles in operation the Harvey Exposure Meter used by many photographers to integrate the many factors affecting the stop and time to use in taking a picture. This new Fire Danger Meter utilizes the measurements of each of the following six factors and integrates their individual effects into an expression of fire danger:

1. SEASON. In early June all vegetation is growing actively, wet with sap, and is therefore a fire retardant. As the season develops, however, these shrubs and weeds mature, dry out, and add to the volume of fuels and the class of danger. The Meter therefore rates fire danger as increasing from April or May to early September, and then decreasing thereafter, as the days become shorter, the cool nights longer, and the normal frequency of rain becomes greater.

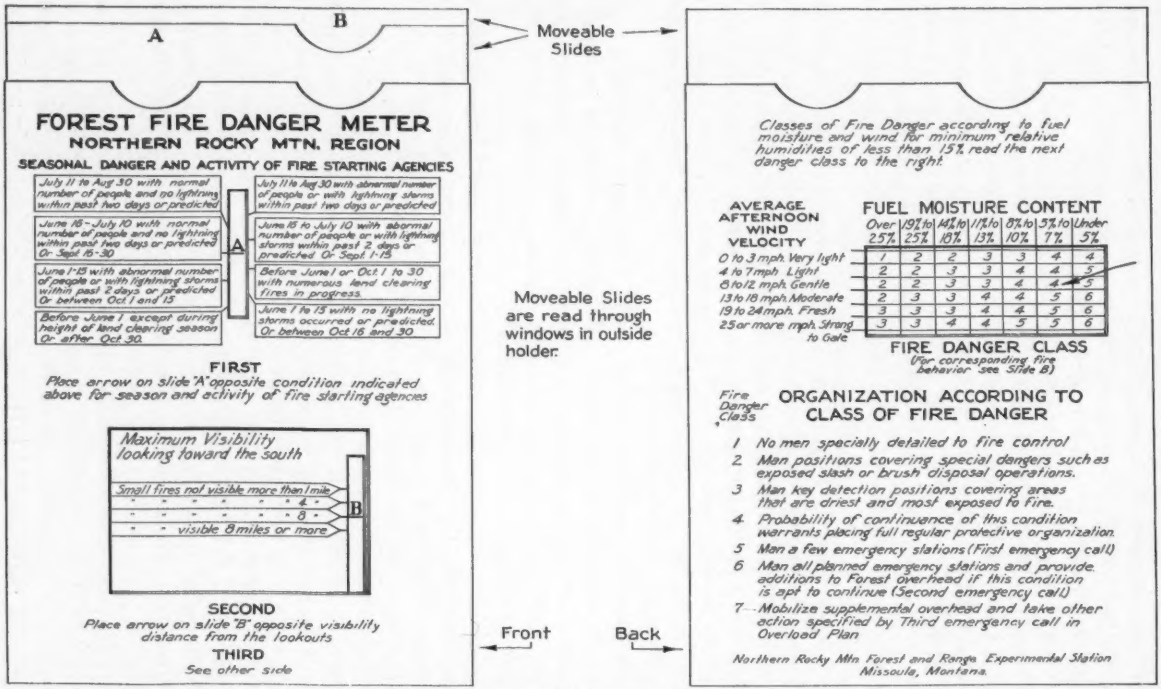
2. ACTIVITY OF THE CAUSATIVE AGENCIES. When more than the normal number of people are within the forests, such as on week-ends or during the berry picking and hunting season, the chances of ignition are increased and the Meter expresses this. Forecasts of lightning or the presence of storms also are accepted as evidence of increased danger.

3. THE VISIBILITY DISTANCE OF SMALL SMOKES. When the atmosphere is so hazy or smoky that small columns of smoke cannot be detected more than one mile away the danger is several classes greater than when the air is clear and such smokes can be discovered eight or more miles away.

4. WIND VELOCITY. Studies of the behavior of forest fires have indicated that certain velocity classes can be defined, each indicating a significant increase in rate of spread of fire, hence fire danger. Classes of danger are therefore stepped up with increased wind.

5. FUEL MOISTURE. The effects of lower moisture content on increased ease of ignition of duff have been studied and several degrees of flammability defined. Higher classes of danger are therefore allocated to these classes of decreasing fuel moisture, as measured by the wood cylinder and duff hygrometer methods.

6. RELATIVE HUMIDITY. Studies of fire behavior have also shown that during periods of exceptionally low humidity there is a decided increase in the rate of spread of fire even though the heavier fuels, such as duff and wood, have not suffered an appreciable loss in moisture. Consequently provision is


A
B
Moveable Slides
FOREST FIRE DANGER METER
NORTHERN ROCKY MTN. REGION
SEASONAL DANGER AND ACTIVITY OF FIRE STARTING AGENCIES
July 11 to Aug 30 with normal number of people and no lightning within past two days or predicted
July 11 to Aug 30 with abnormal number of people or with lightning storms within past two days or predicted
June 16 - July 10 with normal number of people and no lightning within past two days or predicted Or Sept 16-30
June 16 to July 10 with abnormal number of people or with lightning storms within past 2 days or predicted Or Sept 1-15
June 1-15 with abnormal number of people or with lightning storms within past 2 days or predicted Or between Oct 1 and 15
Before June 1 except during height of land clearing season Or after Oct 30
Before June 1 or Oct 1 to 30 with numerous land clearing fires in progress
June 1 to 15 with no lightning storms occurred or predicted Or between Oct 16 and 30
A
FIRST
Place arrow on slide "A" opposite condition indicated above for season and activity of fire starting agencies
Maximum Visibility looking toward the South
Small fires not visible more than 1 mile
" " " " " " 4 "
" " " " " " 8 "
" " visible 8 miles or more
B
SECOND
Place arrow on slide "B" opposite visibility distance from the lookouts
THIRD
See other side
Moveable Slides are read through windows in outside holder.
Front
Back
Classes of Fire Danger according to fuel moisture and wind for minimum relative humidities of less than 15% read the next danger class to the right
AVERAGE AFTERNOON WIND VELOCITY
FUEL MOISTURE CONTENT
Over 25% | 19% to 25% | 14% to 18% | 11% to 13% | 8% to 10% | 5% to 7% | Under 5%
0 to 3 mph. Very light: 1 2 2 3 3 4 4
4 to 7 mph. Light: 2 2 3 3 4 4 5
8 to 12 mph. Gentle: 2 2 3 3 4 4 5
13 to 18 mph. Moderate: 2 3 3 4 4 5 6
19 to 24 mph. Fresh: 3 3 3 4 4 5 6
25 or more mph. Strong to Gale: 3 3 4 4 5 5 6
FIRE DANGER CLASS
(For corresponding fire behavior see Slide B)
Fire Danger Class
ORGANIZATION ACCORDING TO CLASS OF FIRE DANGER
1 No men specially detailed to fire control
2 Man positions covering special dangers such as exposed slash or brush disposal operations.
3 Man key detection positions covering areas that are driest and most exposed to fire.
4 Probability of continuance of this condition warrants placing full regular protective organization.
5 Man a few emergency stations (First emergency call)
6 Man all planned emergency stations and provide additions to Forest overhead if this condition is apt to continue (Second emergency call)
7 Mobilize supplemental overhead and take other action specified by Third emergency call in Overload Plan
Northern Rocky Mtn Forest and Range Experimental Station
Missoula, Montana.

Fire Danger Meter set to show class of fire danger on July 6, with no recent lightning storms, visibility distance 8 miles, fuel moisture 9%, wind velocity 11 m.p.h., and relative humidity 13%. (See text page 328.)

made to rate fire danger higher whenever the humidity drops below 15%. Incidentally, humidities of 5% have been measured in this Northern Rocky Mountain region, and during the period July 21 to 31, 1933, the *average* 4:30 P.M. humidity at Missoula, Montana, was only 13.2%. Such dry air results, of course, in faster rate of spread of fire.

These were the six factors of fire danger which were chosen to be integrated into classes of danger, and their integration depended first, of course, upon the number of classes of danger selected. Seven distinct classes were finally established on the basis of fire behavior and the administrative action possible. Class 1 on this scale indicates that fires will not spread and that no action is necessary for their control, while class 7 indicates that fires may spread at the maximum rate ever observed in this region, i.e., from 1500 to 2000 acres per hour for several consecutive hours. The administrative action to meet such great danger consists, of course, of every conceivable step warranted by the value of the resources at stake. In Region 1 of the Forest Service a quite voluminous "Overload Plan" is devoted entirely to the action to be taken to meet these peaks of danger.*

The six factors of danger have been arranged on the faces and slides of the Fire Danger Meter in such a way that any particular combination of factors would always be integrated by the meter to show the same class of danger. For each combination of these factors a class of fire danger is inscribed within the space provided for that purpose. Hence one man can be consistent in rating danger, and better yet, when several Forest Supervisors use the meter, if they start with the same measurements of conditions they will end with the same rating of danger. This was hardly ever the case when each man selected his own factors and "sized-up" the situation according to his own experience and opinion.

The factors selected for use on the Meter, and the weights given to each factor were studied with great care, however, before they were finally incorporated. In this selection and weighing the results of several years of research measurements were merged with the opinions of some of the most experienced fire control experts in this region. Then the Meter was tested by applying it to the detailed records of all factors as measured over a five-year period at the Priest River Branch of the Experiment Station. Some improvements

*As forest fires frequently originate in large numbers within a short space of time the load of work often increases to a peak or overload for the regular forest protective organization. An overload also results if exceptionally dry, windy weather prevents quick control of a large number of fires. In 1931 a combination of both these conditions resulted in the employment of about 9000 fire fighters at one time on an area of 14,000,000 acres. Adequate supervision of such force is provided for by the "Overload Plan," which specifies the order in which regular forest officers shall be assigned to this work. These men are drawn from all National Forests not, at that time, overloaded with fire control. In one case forest officers from Arizona were on the fire line in northern Montana the day following the issuance of a request for assistance.

were made, as shown desirable by this test, and the Meter was then issued to numerous forest officers for a daily and fully practical test during an entire fire season on thirteen National Forests.

The result of this experimental work is indicated by the illustration, which shows the front and back of a Forest Fire Danger Meter properly set to integrate six factors into one class of fire danger. As shown by the setting of "A," the time is between June 16 and July 10, with no lightning storms having occurred or being predicted, and with only a normal number of people on the forest. "B" is set for slightly less than best visibility, or ease of discovery of small fires. On the reverse side of the Meter the forest executive then finds the column of figures which shows class of danger, according to fuel moisture content and wind. For a 9 per cent fuel moisture and an 11-mile wind he finds class 4 indicated. Obviously this is a low class 4 because it neighbors a class 3. But there is still an allowance to be made for the dangerous relative humidity of 13 per cent, and the directions state that this allowance is made by using the next danger class to the right, equivalent to lowering the fuel moisture by one group. When this is done the rating for that day is found to be a high class 4, bordering class 5, which represents a first emergency condition.

By this method the forest executive is now able to rate fire danger more consistently than in the past, and to express his rating in a simple term easily understood by every other executive or fire control expert familiar with this method. This latter advantage has, in fact, been one of the principal features which has "sold" this method to foresters. For the first time they find themselves able to describe fire danger explicitly and understandably. The contrast with the old procedure of describing degree of danger as "bad," "very bad," and "blankety-blank bad," has emphasized the value of explicit terminology in fire control, much as the editor of the QUARTERLY recently stressed the need of "a unit of measurement of size of fire."

While they welcome this development of forest fire research the foresters in this region are also constructively critical of the particular factors chosen and the weights given to each in rating fire danger. Undoubtedly some changes will be made and the method materially improved on the basis of continued experience and additional research.

Paulsboro, N. J., Linoleum Factory Fire.

A fire, starting in the dryer building at a linoleum manufacturing plant in Paulsboro, N. J., on the night of February 8, 1934, swept through adjoining buildings and resulted in the almost total destruction of this sprinklered plant with a loss estimated in the vicinity of $1,000,000. This fire emphasizes the need of a reliable water supply to automatic sprinklers and hydrants, especially in situations where flash fires are likely to open many sprinklers. It indicates the need for special protection of flat rack drying processes, the arrangement of stock in drying racks in this instance preventing effective distribution of water from the sprinklers at the ceiling. Light joisted construction was a primary factor in the rapid spread of the fire.

Description of Property.

The original buildings at this plant were built in 1914-1915 and were used as a munitions plant. Subsequently the property was purchased by a linoleum manufacturer, and gradual expansion resulted in an arrangement and construction of buildings as shown by the accompanying diagram. The main group of buildings was subdivided by fire walls of brick and cinder block. The ground floors were mainly concrete, but other floors were light frame on joist. The majority of the roofs were of open joisted and semi-mill construction and it is estimated that 45 per cent of the walls were of cinder block construction, 45 per cent were brick and 10 per cent were frame.

This plant manufactured a printed, asphalt-impregnated, paper-felt base floor covering. The felt base was coated in the Printing Building (No. 8-D) with a primer of resin, linseed oil, and china wood oil, printed with paints thinned with petroleum distillate (flash point 107.6° F.), and then placed in the Flat Rack Drying Building (No. 8) for curing. Printed linoleum was coated with clear pyroxylin lacquer and dried in the Festoon Dryer Building (No. 8-A) adjoining, but this was not a factor in the start of the fire.

In the Flat Rack Drying Building the linoleum, in strips 182 feet long by about 9 feet wide, was arranged horizontally on racks 20 feet high, the strips being an average of four inches apart. The supports for the racks were of wood with iron pipes extended horizontally between them. Wires were laid lengthwise of the racks for further support. Slatted wooden walkways were provided between the racks which, with the supports, made considerable wooden construction in this area. The building contained eight racks, the

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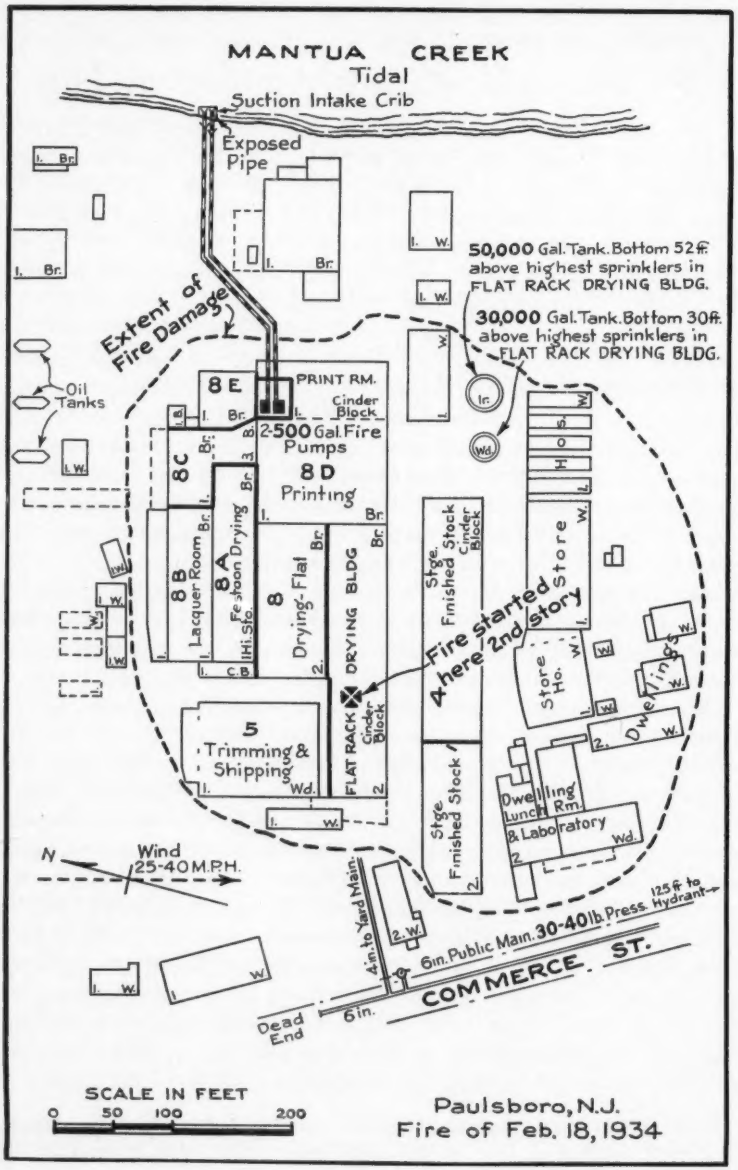
This report has been prepared largely from data furnished by the Factory Insurance Association (Member N.F.P.A.), supplemented by information obtained from other sources.


MANTUA CREEK
Tidal
Suction Intake Crib
Exposed Pipe
50,000 Gal. Tank. Bottom 52 ft. above highest sprinklers in FLAT RACK DRYING BLDG.
30,000 Gal. Tank. Bottom 30 ft. above highest sprinklers in FLAT RACK DRYING BLDG.
Extent of Fire Damage
Oil Tanks
8 E
PRINT RM.
Cinder Block
2-500 Gal. Fire Pumps
8 C
8 D
Printing
8 B
Lacquer Room
8 A
Fashion Drying
Hi. Sfc.
8
Drying-Flat
DRYING BLDG
FLAT RACK
Cinder Block
Stge. Finished Stock
Cinder Block
Fire started here 2nd story
Store
Store Ho.
Dwellings
5
Trimming & Shipping
Stge. Finished Stock
Dwelling Lunch Rm.
& Laboratory
Wind 25-40 M.P.H.
N
4 in. to Yard Main.
6 in. Public Main. 30-40 lb. Press.
125 ft. to Hydrant
COMMERCE ST.
Dead End
6 in.
SCALE IN FEET
0 50 100 200
Paulsboro, N.J.
Fire of Feb. 18, 1934

capacity of which was approximately 80 tons. The drying rooms were heated by steam coils to a maximum temperature of 150° F.

Fire Protection.

A modern wet-pipe system of automatic sprinklers with standard spacing covered all portions of the main group of buildings and the warehouse. The west, or "cinder block" section of the Drying Racks, had 213 sprinklers, while the north and south sections of Building No. 8 contained 564 sprinklers. These sprinklers were at the roof, or at the ceiling of the first story. There was also a system of yard hydrants for outside protection. The underground pipe system was fairly well arranged, except for the fact that all yard hydrants but one were on 4-inch mains.

The entire system was supplied by a 50,000-gallon steel gravity tank, 52 feet above the highest line of sprinklers; a 30,000-gallon wooden tank, 30 feet above the highest line of sprinklers; two 500-gallon fire pumps taking suction from Mantua Creek (tidal) under a 6 to 11-foot lift; and a 4-inch connection from a dead-end 6-inch public main at 40 lbs. pressure.

The fire pump suction pipes extended to a wooden crib located about ten feet from the bank of the creek. These pipes were exposed between the bank and the water level, especially at low tide. The foot valves on the suction pipe were located within six inches of a soft mud bottom and at low tide only two feet of water covered the valves.

Public fire protection was from a volunteer fire department consisting of two companies equipped with one 750-gallon pumper, three 500-gallon pumpers and a chemical engine. A long 6-inch dead-end main extended to the plant with one hydrant in front of the office building and another about 200 feet distant from the property.

Weather Conditions.

The weather on the night of the fire was extremely cold, with a temperature of approximately zero at 11 P.M., falling to 2° below zero at midnight, and reaching an all-time low mark of 11° below zero at 8:15 A.M., February 9th. A 25-mile wind was blowing from the north. There was an inch or more of snow on the ground. The relative humidity as recorded by the U. S. Weather Bureau at Philadelphia was 27 per cent at 8 P.M.

Story of the Fire.

The plant was in operation with a staff of about twenty men, most of whom were in the Print Room. A new lot of freshly printed material had been placed in the Flat Rack Dryer and five racks were being operated.

Everything seems to have been satisfactory up to 9:00 P.M., the recording temperature readings taken by the watchman being 110° F. On his 9:00 P.M. round, however, the watchman noted an unusual amount of gas present

International.

Airplane view of burning linoleum plant at Paulsboro, N. J., with frozen creek in left foreground. A strong wind carried a shower of burning embers over the town, but fire departments from several communities, aided by snow on the roofs, prevented a general conflagration.

in the dry racks and he so reported to the Print Room foreman, who gave instructions to close the valves controlling the steam coils, which the watchman did. On the 10:00 P.M. round excessive gas was noted, but as no increase in temperature was apparent no further action was taken.

The watchman, on his 11:00 P.M. round, was about to enter the second floor of the Flat Rack Dryer from the stairway outside the building, when he noticed a brisk fire in progress between the layers of linoleum on the rack. He did not observe any sprinklers in operation at that time. He closed the fire door (door found closed after the fire) and notified the Print Room foreman. The factory whistle was immediately sounded, the public fire department notified by telephone, and the fire pumps started. Meanwhile employees stretched hose lines from yard hydrants to the roofs of the Printing Building (No. 8-D) and the Warehouse (No. 4), intending to direct streams into the second floor of the Flat Rack Drying Building.

The Paulsboro Fire Department arrived about ten minutes after the alarm was received. At that time flames were coming from the monitor on the cinder block section of the Flat Rack Drying Building. The chief states that the sprinklers were operating, which statement was confirmed by the Print Room foreman, who observed water coming from the dry racks on to the print room floor. The fire department stretched four hose lines from the two available street hydrants, operating from the roof of Building 8-D and from the areaway to the south. Two streams were also used for a short time from pumpers located at Mantua Creek, but were of little value, owing to difficulties in getting suction due to the extreme low tide and ice.

Camden Courier-Post.

View of ruins of Paulsboro linoleum plant, showing complete destruction of building and contents.

In about half an hour it was thought that the sprinkler system had gotten the fire in hand and with hose streams it would be possible to confine the fire to the Flat Rack Drying Building, but at this time the water supply failed. The heavy draft of the many opened sprinklers, together with the hose streams from the yard hydrants, emptied the gravity tanks. Although the fire pumps had been started promptly, they were abandoned after attempts to get water were unsuccessful. This failure was due to an exceptionally low tide and unusual ice conditions caused by prolonged cold weather.

After the tank supply was exhausted, all plant efforts were necessarily abandoned. The streams of the fire department were inadequate to cope with the fire which, driven by the strong north wind, quickly spread to adjoining buildings. Within a short time fire had spread to the Printing Building and to the Finish Stock Warehouse (No. 4), 30 feet to the south. From the warehouse it spread to the group of unsprinklered frame storehouses, laboratory, lunchroom, and dwellings, which were quickly destroyed.

In the main group of buildings the fire was somewhat retarded by fire walls, but by one o'clock the major portion of the plant was well involved. The fire communicated to the various buildings by way of the roofs, the walls either being without parapets or the parapets being too low. The last building to burn was the frame Trimming and Shipping Building (No. 5), located north of the Flat Rack Drying Building where the fire was first observed. That this building was the last to be destroyed may be explained by the fact that the north wall of the Drying Building was a blank brick wall.

The gravity tanks were subjected to intense heat, the tower and 8-inch drop pipe of the smaller wooden tank being badly warped, while the tower

of the larger steel tank was slightly warped but not seriously damaged. The wooden tank was badly charred and the roof burned off.

Fire Fighting Operations.

As has already been indicated, the sprinkler system apparently functioned properly, but the arrangement of stock in the drying racks prevented effective distribution and in spite of the fact that all heads probably opened, the fire quickly spread throughout the room. The hose streams taken from the yard mains were very weak and entirely ineffective.

It is believed that both sprinkler tanks were full at the time of the fire, which should, under normal conditions, have permitted the use of two hose streams as well as the sprinklers for a limited period. Subsequent investigation, however, disclosed a water-soaked board in the 50,000-gallon tank riser, so located that it covered the 8-inch riser leading to the underground system in such a way that the area of the riser was reduced to that of a 3½-inch pipe. This obstruction in the primary water supply accounts for the lack of available water supply for hose streams as well as sprinklers in the early stages of the fire.

The failure of the fire pumps has been explained as due to an unusually low tide and ice conditions brought about by the extreme cold weather. At the time of the fire the creek was practically dry and whatever water was near the crib was frozen solid. The U. S. Army Engineers office in Philadelphia reported a record low tide on the night of the fire for the entire area.

Several communities in addition to Paulsboro responded to calls for assistance, sending men and apparatus, including eight pumpers. Lack of adequate water supplies restricted fire department activities, and efforts were mostly centered on saving detached plant buildings and dwellings in the town, which were mostly of frame construction with wooden shingle roofs. In spite of a shower of burning embers, these efforts, aided by snow on the roofs, prevented a general conflagration. The firemen were handicapped by the freezing of hose lines and the freezing up of several of the pumpers. All of the fire departments engaged at the fire were volunteer organizations.

Fire Department Operations—As Reported by Local Fire Chiefs.

Town	Called at	Time of Run Min.	Approx. Distance Miles	Motor Pumper	Other Apparatus	No. Streams	No. Men
Paulsboro							
Billingsport Co.	11:20 P.M.	3	0.6	2	—	2	20
Paulsboro Co.	11:25 P.M.	3	1.0	2	1	5	25
Woodbury	12:05 A.M.	13	6.0	1	—	0	20
National Park	12:20 A.M.	15	7.0	1	1	0	20
Gibbstown	12:30 A.M.	7	3.25	1	—	1	17
Clarksboro	12:40 A.M.	10	2.5	—	1	0	10
Mount Royal	—	No data					
Swedesboro	—	No data					

Cause and Loss.

This fire may definitely be attributed to the rapid oxidation of materials used in printing linoleum during the drying process. This conclusion is supported by the watchman's statements as to the excessive amount of gas noted as early as 9:00 P.M., which condition prevailed up to the time of discovery of the fire.

Definite information as to the loss is not available, but reliable estimates place it in the vicinity of $1,000,000, including use and occupancy loss of approximately $350,000.

Birmingham Department Store Fire.

Report by South-Eastern Underwriters Association,
(Member N.F.P.A.)

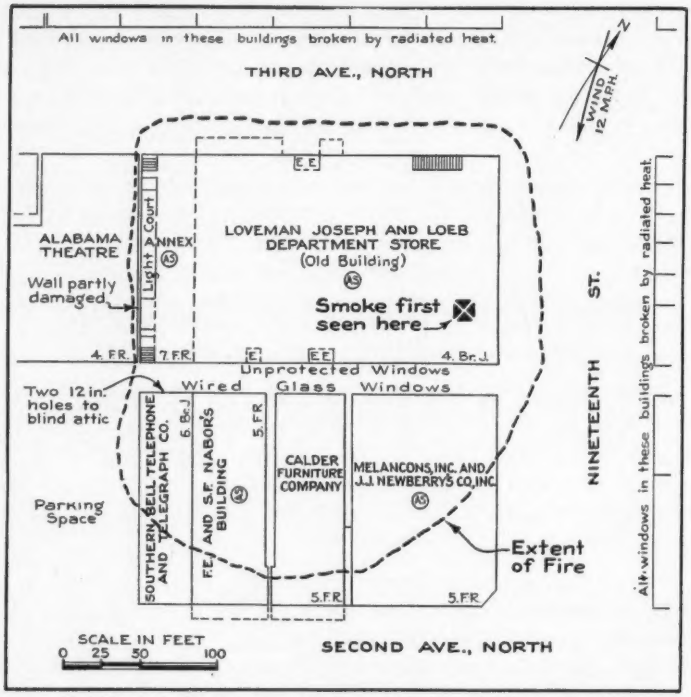
An unsprinklered space beneath the grade floor was the place of origin of a mid-day fire, which eventually destroyed the large sprinklered department store of Loveman, Joseph and Loeb in Birmingham, Ala., on Saturday, March 10, 1934, with serious damage to several other buildings. A delay in calling the fire department, and ineffective fire fighting were also important factors in the loss, which is estimated at $2,000,000.

Property Involved.

The department store building where the fire started consisted of two communicating sections, essentially one building. The older section, erected about 1895, was four stories high with a blind attic. It was of brick-joisted construction 135 x 200 feet in area with an open stairway extending from the first to fourth floors. Two elevator shafts extended from a partly excavated space under the first floor to the fourth floor. There was a small basement under part of this section, and the unused partly excavated space approximately five feet high extended under the remainder. Unprotected openings led from the main basement to the unused space. Small ventilators were provided from the unused space venting to the street level.

Brick cross walls, ten feet on centers, divided the area under the store into fourteen bays. These walls were built from the ground to the bottom of the floor joists and extended approximately the entire length of the space from east to west. Each bay thus formed communicated with adjoining bays through spaces between the floor joists resting on top of the cross walls and by means of a cross tunnel extending north and south, adjoining the basement retaining wall.

The new section of the building, erected in 1917, was of fire-resistive construction, but not cut off in any way from the brick portion. This section was seven stories high, with a basement under the entire area. Floor openings were enclosed. With the exception of a small elevator shaft, which ex-



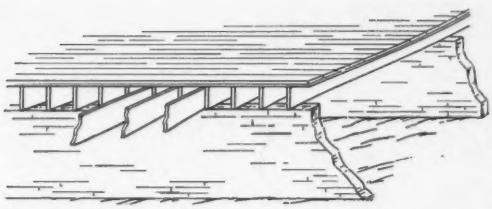
Buildings involved in Birmingham, Ala., fire of March 10, 1934.

tended from the basement shipping room to the first floor in the old section, the only means of entering the entire basement (both sections) was by the stairways in the fire-resistive section.

Windows were plain glass except those in the fire-resistive section facing the light court on the west, which were wired glass. Metal shutters were provided for the windows on the south side, but these were open at all times.

Both sections of the building were equipped with a wet pipe sprinkler system covering all portions except the space under the first floor where the fire started. There were two sources of water supply, one of which was from city mains, providing pressure and volume which would have been more than adequate under ordinary circumstances. The other was from a 40,000-gallon gravity tank elevated above the roof of the seven-story annex.

Adjoining the fire-resistive section of the department store on the west was the blank wall of the fire-resistive Alabama Theatre. Across a twenty-foot alley to the south were four buildings, three of fire-resistive and one of brick-joisted construction. All had wired glass windows in metal frames facing the



Construction in space beneath first floor of Loveman store. Brick walls running east and west formed fourteen bays about 10 feet wide and 150 feet deep, with five feet head room. These bays communicated north and south through joist channels.

alley, but the brick-joisted building had two small unprotected openings at the roof line, through one of which a beam projected. One of the fire-resistive buildings was equipped with automatic sprinklers and another had a sprinkler system which had been shut off for several years.

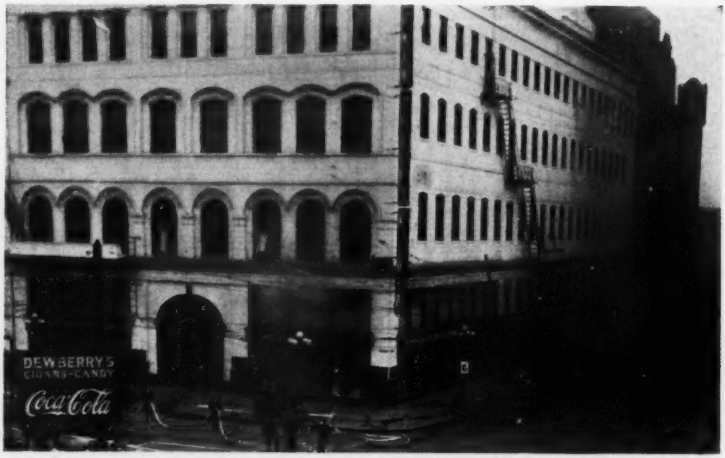
Origin and Discovery of the Fire.

The fire started in one of the bays in the unused space under the first floor in the southeast section of the building. The cause has not been definitely determined, but it is thought to have been defective electrical wiring. Most of the wiring in the space under the first floor was installed years ago and the location was favorable to insulation deterioration. Recommendations had been made to improve wiring conditions, but the suggested changes had not been made. Branch circuits were uniformly overfused, with main feeder circuits protected mostly by obsolete link fuses. Many of these feeders were also overfused.

The fire was discovered at about 12:30 P.M. by the floor superintendent, who smelled smoke in the vicinity of the jewelry department on the first floor of the store building. After a brief investigation a faint trace of smoke was noted emerging from the space beneath the floor around a small opening for a show case wiring connection. The presence of fire under the floor was verified when it was noticed that the floor was hot. The floor superintendent immediately summoned the building manager and the electrician from the basement by telephone. They responded at once, traveling a distance of nearly 300 feet, and arriving at about 12:35 P.M. A well-advertised sale was in progress and store employees were notified to get the large number of customers from the building as soon as possible.* At this time smoke was only evident by a slight haze and its source could not be definitely ascertained.

The electrician, suspecting that wiring under the floor was involved, cut off the show case lights in the jewelry department, while the building manager returned to the basement and cut off all show case lights and cash register motors on the entire first floor. On their return to the basement both men went into the area beneath the first floor. One of them went up the bay

*Newspaper accounts place 3500 persons in the store at the time of the fire.

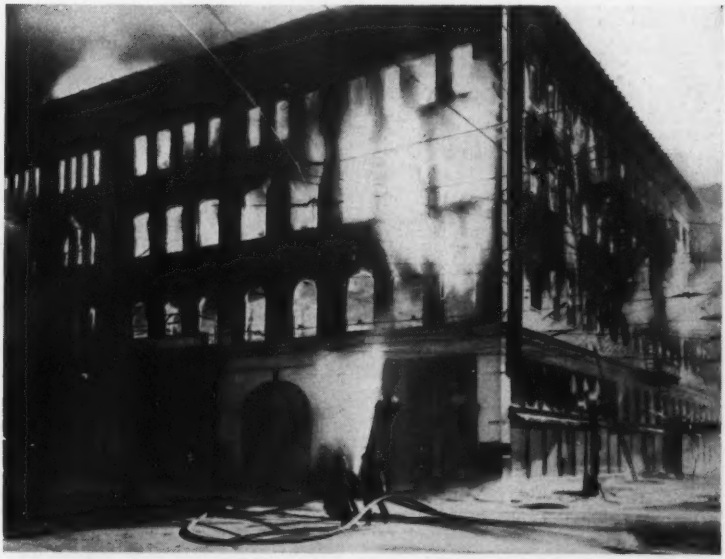


Looking southwest from the corner of 3d Ave. and 19th St. at about 1:30 P.M. The fire is still confined to the basement. Note smoke venting from transoms on the first floor and from elevator shaft windows on 3d Ave. side.

directly in front of the opening from the shipping room, proceeding about seventy-five feet. He encountered dense smoke but saw no fire, so he returned to the shipping room. The other man, armed with a 1-quart carbon tetrachloride extinguisher, entered the adjoining bay and proceeded to a point not far from the building wall. He states that he operated his extinguisher on three glowing (not flaming) joists, darkening them. He does not recall seeing any fire in adjoining bays.

Progress of the Fire.

At 12:40 P.M. the fire department received an alarm by telephone from the floor superintendent, perhaps ten minutes after he first discovered the fire. The chief and companies from four stations with a complement of sixty men reached the store at 12:43 P.M. Two firemen with a 2½-gallon soda-acid extinguisher entered the basement and were informed by one of the men emerging from the fire area that it was only a small fire, but that, although he had put it out with his extinguisher, they had better see for themselves. Thereupon the two firemen entered the fourth bay and about twenty feet from the far end found several joists burning. They extinguished the fire at this point, but noted that fire was sweeping through the joist channels from the north. Returning to the shipping room they reported to the chief that the fire, accompanied by dense smoke, was spreading rapidly through the joist channels and that the best method of attack would be to cut holes through the first floor over the affected area.



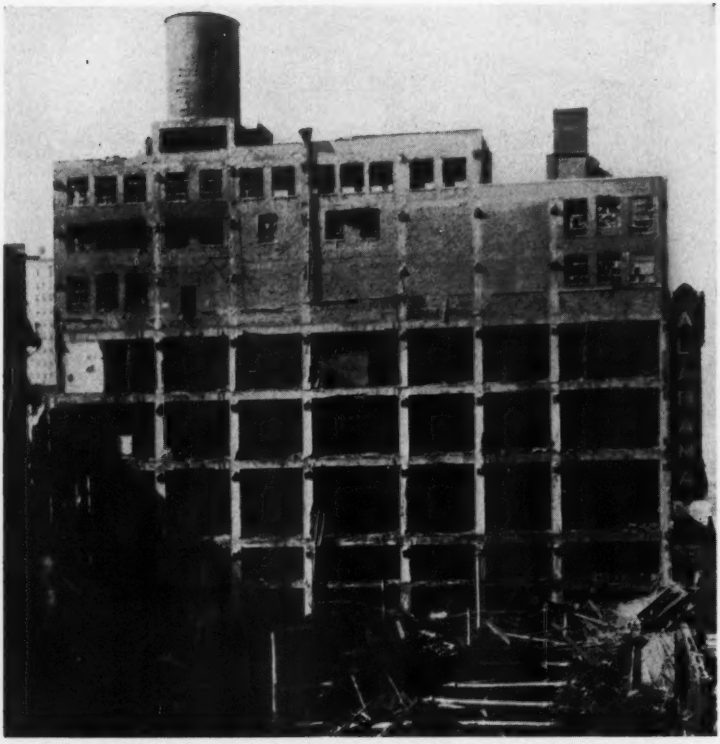
International.

This picture shows the flames in full control of the upper floors a short time after the flash, which occurred at 3:28 P.M. No fire on first floor.

The chief then proceeded to the first floor (approximately 12:50 P.M.) and found that one hole had already been cut about twenty feet from the south entrance on Nineteenth Street. Other holes were cut in this area, hose lines were taken down short ladders into them and the fire driven back from the immediate vicinity. A strong odor of burning insulation was noticeable. At 1:10 P.M. a second alarm was sounded, bringing four additional companies and calling a portion of the off-shift. By 1:30 P.M. twelve holes had been cut in the floor across practically the entire store front within 30 feet of the outside wall. No holes were cut in the show window spaces.

Extreme difficulty was experienced in getting at the fire due to the construction under the floor, and without smoke mask protection the firemen suffered severely from smoke and noxious gases. Elevator penthouse doors were opened shortly after the arrival of the fire department, but no other ventilation was attempted, except by opening transoms and breaking small windows over the show windows on the first floor. Smoke and highly combustible gases from the fire area gradually filled the upper three floors, entering by way of elevator shaft openings and the open stairway.

At 3:28 P.M. observers saw the fire flash up the elevator shaft on the alley side of the building and almost instantaneously the entire building



Ruins of the Loveman store, showing gutted fire-resistive annex with sprinkler tank intact on roof. Note beam at hole where fire entered under roof of telephone building at extreme left of picture.

seemed to burst into flame, except the first floor, which did not become involved until the upper stories had been burning for some time. This is partly accounted for by the ventilation of the first floor. At 3:40 P.M. the fire communicated to near-by buildings and a general alarm, summoning all but two companies, was sent in at 3:53 P.M. By 4:30 P.M. the fire had completely destroyed the old brick section of the store, gutted the fire-resistive annex, and, aided by the wind, had entered the four buildings across the alley, where the main efforts of the fire department were concentrated.

The fire was fought by the entire Birmingham fire department (with the exception of two companies), aided by one pumper each from Bessemer, 13 miles distant, and Tarrant, 6 miles distant. During the course of the fire no difficulty was experienced with equipment or hose. The water supply was adequate, the volume being sufficient and the lowest pressure recorded during the fire was 77 lbs. Hourly records of the Birmingham Water Works Com-

pany indicate an excess pumpage of 4,500,000 gallons on the day of the fire, of which it is estimated that 225,000 gallons were used to combat the fire in the store basement prior to its flash through the upper floors.

The fire department was handicapped by a limited supply of special and heavy stream appliances, by lack of smoke masks (particularly of the oxygen type) and by the absence of special lighting equipment, which would have penetrated the dense smoke inside the store. It is doubtful if much water reached the fire in its early stages, due principally to construction features under the floor, and to the fact that ordinary nozzles rather than those of the distributing type were largely used. The few filter-type smoke masks on hand were not used; sponges and wet handkerchiefs were relied upon instead, with the result that more than fifty firemen were more or less affected by smoke and gases.

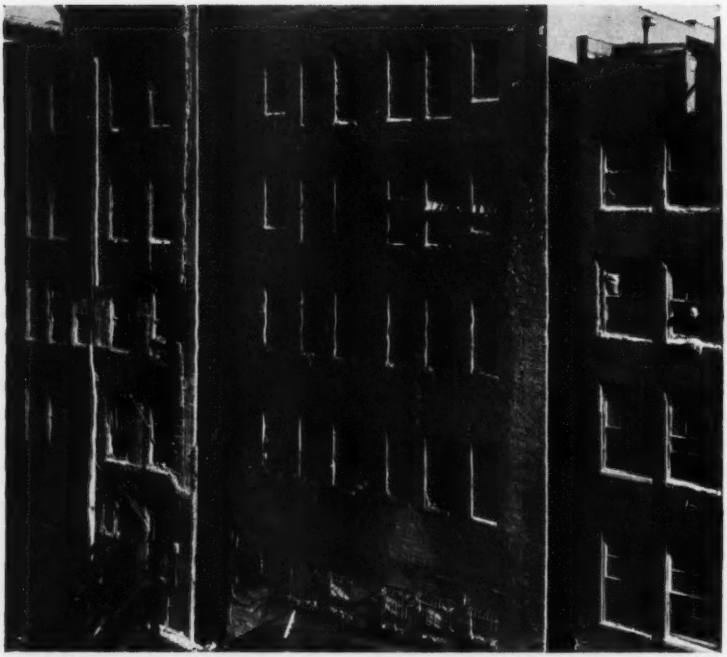
Allowing for the usual discrepancies in the time element in determining the approximate time of discovery of the fire, it is probable that the apparent delay between the time of discovery and the arrival of the firemen mitigated against the chance of success on the part of the fire department in controlling the apparently incipient blaze. This delay gave the fire an opportunity to gain headway and spread over the entire area under the first floor where it soon exhausted the oxygen available, then smoldered for nearly three hours on the limited supply that could be received through the small street vents, basement openings and holes cut in the floor by firemen. This condition produced the effects of wood distillation in the form of a large quantity of smoke and heated, unburned, flammable gases. These filled the unventilated upper floors and created an ideal condition for the rapid propagation of flame over these floors when ignited by fire flashing up the vertical openings.

Operation of Sprinkler System.

The entire building, except the space under the first floor where the fire started, was protected by a wet-pipe sprinkler system. It is believed that the system was in commission at the time of the fire, although no witnesses were found who actually saw water coming from a sprinkler head. During the first stages of the fire there was not sufficient heat to operate the sprinklers on the first floor and apparently the gases which filled the upper floors were not hot enough when mixed with air on these floors to open sprinkler heads there until ignition occurred at 3:28 P.M. The magnitude and intensity of the flash which enveloped the upper floors undoubtedly fused simultaneously most of the heads (approximately 1000) above the first floor, obviously a greater number than could be effectively supplied.

Communication of Fire to Other Buildings.

At about 3:40 P.M. open sprinklers on the adjoining fire-resistive department store of Melancon's Inc., were put into operation. At the same time fire, entering this building by way of wired glass windows which were not



Looking across the alley after the fire. From left to right: Melancon's, Calder's, Nabor's. All windows were of wired glass in metal frames. Note open sprinklers over windows of Melancon's and spalled brick work of the Calder building. A falling wall damaged the right windows of Melancon's.

tightly closed, operated the sprinkler system as recorded by the central station water flow signal. The automatic and open sprinklers were an important factor in preventing the spread of the fire in this building, for the fire department used but two hose streams on this property.

Intense heat penetrated the wired glass windows of the Calder Furniture Co. building and ignited the contents. The fire gained such headway before the fire department could shift operations to protect exposures on Second Avenue that the two upper floors were gutted and the stock on other floors was ruined by the water necessary to bring this fire under control. The fire department apparently did not appreciate the extreme exposure involving the Calder building, which was without any automatic sprinkler protection, and their failure to provide hose streams promptly on at least the upper floors was responsible for the fire gaining such headway in the building.

The Nabor's building had been vacant for several years, with all fixtures removed to top floor storage. Fire, entering through wired glass windows on the top floor shortly after 3:40 P.M. (and some time later on the next floor),

burned with but little attention from the fire department until about 4:45, when it was discovered that the sprinkler system was shut off, a condition which had existed for several years. One pumper was then connected to the fire department connection on the sprinkler system, which held the fire in check, requiring little further attention on the part of the department. As far as can be ascertained, this is the only instance of use of the fire department connections on any of the buildings involved at this fire.

Fortunately, the telephone building was somewhat protected by the fire-resistive annex of the Loveman building. As a consequence, the actual fire damage was not relatively great. In this building wired glass windows prevented the fire from entering the various floors, but two unprotected openings (each about 12 inches in diameter) into a blind attic permitted the fire to enter and severely damage the roof. Firemen, using two hose lines from the building standpipe connections and one line from the street, confined the fire to the roof space. However, as use of tarpaulins was limited, the large amount of water used, wet down the telephone equipment on all floors. The water pressure on the standpipe system was found to be adequate without resorting to use of fire department connections.

Damage.

The loss to the department store of Loveman, Joseph and Loeb, was total to the old building, and the fire-resistive annex was probably so badly damaged as to make its removal necessary. The actual monetary loss has not been definitely ascertained, but will undoubtedly be in excess of $1,000,000.

The telephone company probably suffered the next heaviest loss, estimated in the vicinity of $250,000. The damage to the building consisted of a burned roof only, but the loss resulting from water on telephone equipment was heavy.* The loss to the building of Melancon's, Inc., was about $25,000, with a contents loss of approximately three times that amount. The damage to the building was largely confined to the replacement of a section of the alley wall. Probably ninety-five per cent of the contents loss was due to water.

The Calder Furniture Co. suffered a building and fixture loss in the vicinity of $50,000, with a virtual total loss to stock estimated at $12,000 to $15,000. About $5000 of this represents direct fire damage on the two top floors, and the remainder was water loss on floors below.

The Nabor's Building was vacant at the time of the fire, except for storage of fixtures on the top floor. The loss was confined to the two upper floors and will not exceed $10,000. The Alabama Theatre, adjoining the Loveman store building, was damaged to the extent of some $10,000.

These major loss items, together with miscellaneous scattered losses, will bring the total loss by this fire to approximately $2,000,000.

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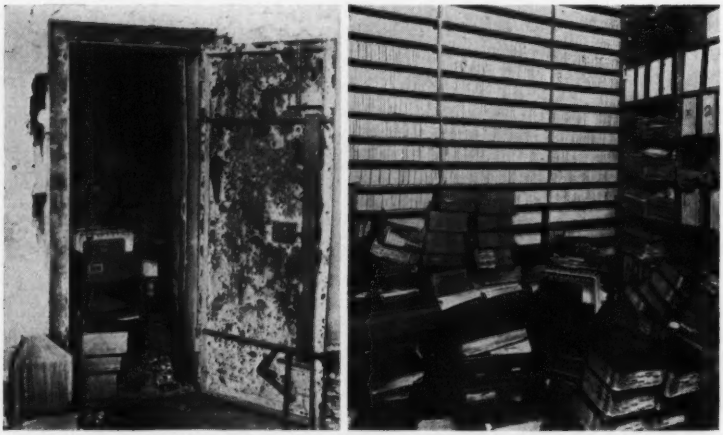
*Press reports state that approximately 8000 telephones were put out of commission temporarily, service being restored at the rate of about 450 per day, beginning the day following the fire.



The vault on the fourth floor of the fire-resistive section of the Loveman building. The condition of the paint on the inside of the inner door would indicate that the door assembly was close to the point of failure (uninsulated steel vault doors test at about 30 minutes on the standard time temperature curve).

There is no indication of serious record losses. The Loveman vault was located on the fourth floor of the fire-resistive annex and, while subjected to considerable heat, preserved its contents intact. There was plenty of time for employees to collect any records that were out of the vault and place them inside.

Conclusions.

The fire department was not handicapped in fighting this fire by lack of water or by severe or unusual weather conditions, but they were considerably handicapped by the arrangement of the area in which the fire originated. It appears that the main features that would have aided the fire department in the early stages would have been: (1) A more thorough knowledge of the construction and arrangement of the building, (2) a predetermined method of attack on this area which was of considerable potential fire hazard, (3) proper equipment for penetrating to the seat of such fires and (4) the necessary training in combating the unusual circumstances encountered at this fire.

It was evident that the fire was burning with a greatly restricted oxygen supply and it is possible that this supply could have been reduced to a point where fire would have been extinguished by suffocation. It does not appear that the fire department was aware of the fact that the smoke filling the upper floors was essentially composed of flammable gases, as very little attempt was made to ventilate this section. The first floor, however, was adequately ventilated to permit the firemen to continue to hopelessly direct hose streams into space under the floor. Had the upper floors been fully ventilated it is doubtful that fire would have ever spread to these sections.

It can also be seen that the sprinkler system was completely overpowered and due to the nature of the fire it was not a factor in preventing the spread of the fire. The area in which fire originated, while not generally used, was occupied by equipment connected with the service of the building and it was often necessary to gain access to this section in that connection. This section was not adequately separated from the other portions of the building and was not provided with sprinklers. Had this space been sprinklered there is no doubt that the sprinkler system would have controlled the fire in its incipiency and without appreciable loss. With the exception of this space the building was fully protected by the sprinkler system, but it would have been absolutely impractical to provide a system capable of controlling a fire of the proportions this one assumed when it flashed from the unsprinklered space.

The type of building construction used in the space under the floor was obviously undesirable. The open communications over the cross walls between the joist channels permitted the spread of fire in this area and the fact that vertical openings communicated with this space permitted spread over the entire building. The first condition could have been reduced by adequate fire-stopping between joists and there was certainly no reason why the construction could not have been arranged to keep the elevator shafts from communicating with this space.

When the Loveman building was doomed, the fire department after some delay directed their efforts to preventing the spread of fire to the exposed buildings and, while the fire was eventually confined to them, the department was greatly aided by the construction of these buildings, including the protection provided against exposure fires, and also by the automatic sprinklers provided. It appears that the general alarm should have been given sooner, as the additional men and equipment were badly needed to prevent fire from entering the buildings across the alley. Had proper steps been taken to save these buildings when it was first evident that fire would assume such large proportions the subsequent damage to them would have been relatively small. The wired glass windows held as well as could be expected in view of the intense heat. The walls of exposed buildings were damaged, partly by falling walls of the Loveman building, but as a whole they held up very satisfactorily. The fire department either erred in not stationing firemen with hose lines in exposed buildings to prevent spread of fire through these buildings or else they were handicapped by lack of sufficient men to cope with the situation.

Conditions disclosed in reference to the electrical wiring in the Loveman building clearly demonstrate the potential fire hazards introduced by lack of proper maintenance of such equipment. The disregard of this hazard, which had been previously pointed out to the management, can only be attributed to their hesitancy in assuming the considerable expense necessary to revamp the electrical system.

Bakery Fire Record.

The total number of bakeries in the United States in 1929, the latest year for which complete figures are available, was 20,785. Production figures for that year show the value of the products of bakeries to have been more than a billion and a half dollars, of which $789,011,311 was added by bakery processes. The average number of wage earners dependent upon the baking industry for employment was 200,841.

National statistics relative to bakery fires and losses are not available, but the following data covering several states, compiled from figures obtained from the U. S. Census of 1929 and reports of the various State Fire Marshals, are presented as indicative of the relative frequency of bakery fires. The relation of losses to values involved will be indicated by typical examples included elsewhere in this record.

State	Total Establishments	Av. No. of Fires Annually
Illinois	2208	66
Iowa	404	21
Kansas	282	11
Massachusetts	1077	26
Wisconsin	711	12

The files of the Department of Fire Record of the National Fire Protection Association contain reports on more than seven hundred bakery fires, including all classes of bakeries from the large modern wholesale baking plant to the small general bakery found in the smaller cities and towns. A brief bakery fire record published in the QUARTERLY for July, 1922 was based on reports of 407 fires that had been filed up to that time. The present fire record brings the former record up to date.

In compiling the data contained in this record, all bakery fires reported to this Association from 1900 to 1933 inclusive have been included. A total of 760 reports of bakery fires have been analyzed, and this analysis has been supplemented by data extracted from a number of State Fire Marshals reports and reports of Insurance Fire Patrols.

The record is by no means complete and does not include many of the small fires which are occurring daily in bakery properties. Insurance inspection bureau reports are the source of data on the majority of bakery fires, supplemented by reports based on newspaper accounts which have been verified through the coöperation of N.F.P.A. members.

In view of the character of the original data, which include most of the larger and more important fires but not a fair proportion of the smaller fires, this record may not be completely representative. The record, however, includes a sufficiently broad selection of the important bakery fires so that there can be no question as to the validity of conclusions drawn in the tables here.

The following table is indicative of bakery loss experience over a ten-year period from 1923 to 1932 inclusive in two states and one large municipality. The greater average loss per fire in the City of Philadelphia is due to a single large loss in 1926 amounting to $539,403. Deducting this loss from the tabulation, the total loss for the remaining 282 fires during the period was $291,437, an average loss per fire of $1033.

Fires and Losses in Bakeries—1923-1932 Inclusive.

Year	State of Massachusetts		State of Iowa		City of Philadelphia	
	Fires	Loss	Fires	Loss	Fires	Loss
1923.....	41	$46,425	20	$19,543	32	$17,194
1924.....	36	93,026	24	70,697	29	28,943
1925.....	27	31,664	29	62,376	34	41,910
1926.....	33	34,280	19	10,327	29	615,019
1927.....	19	88,392	15	14,174	28	35,391
1928.....	17	49,810	24	18,930	28	31,316
1929.....	30	18,470	20	10,398	28	13,382
1930.....	18	70,832	16	12,181	25	32,435
1931.....	24	40,334	15	15,957	26	5,399
1932.....	13	19,178	27	22,506	24	9,851
Total—10 yrs..	258	$492,411	209	$257,289	283	$830,840
Av. loss per fire		$1,831		$1,231		$2,936

These figures include all bakery fires — both in wholesale and retail establishments. Considering these loss figures from the viewpoint of distribution between buildings and contents, it may be noted that in Massachusetts and Philadelphia the loss on buildings amounts to approximately 60 to 65 per cent, while in Iowa it is but 40 per cent.

Distribution of Losses.

	Massachusetts		Iowa		Philadelphia	
	Total	Per Cent	Total	Per Cent	Total	Per Cent
Loss buildings.....	$291,393	59.2	$105,098	40.8	$549,287	65.5
Loss contents.....	201,018	40.8	152,191	59.2	281,553	34.5
Total loss.....	$492,411	100.0	$257,289	100.0	$830,840	100.0

Other loss data are available for shorter periods from the States of Illinois and Kansas and the Province of British Columbia. Illinois, exclusive

Lack of adequate private protection, a delayed alarm and insufficient water supplies for fire fighting were factors responsible for a loss estimated in the vicinity of half a million dollars at the plant of the Freihofer Baking Co. in Allentown, Pa., on April 6, 1932.

Fire Engineering.

Another view of the burning Freihofer Bakery at Allentown, Pa., showing the progress of the fire, which resulted in the destruction of tons of baking materials and products.

of the City of Chicago, had 152 bakery fires in the four-year-period 1929-1933, involving a total loss of $161,942—an average loss per fire of $1065. Kansas, in the three-year period 1926 to 1928 inclusive, had 32 fires in bakeries, involving a total loss of $257,309, of which $213,810 was in two fires occurring in 1928. The statistics for British Columbia cover nine years, from 1924 to 1932 inclusive, and show 36 fires, involving a total loss of $67,381, making an average loss of $1871. These figures seem to bear out the value of the average loss per fire as a satisfactory index for determining relative losses for this type of occupancy.

Analysis of Bakery Losses—N.F.P.A. Fire Record.

Loss	Sprinklered Fires	Sprinklered Per Cent	Unsprinklered Fires	Unsprinklered Per Cent	Total Fires	Total Per Cent
Small loss (under $1000)	287	82.5	207	50.2	494	65.1
$1000 but under $10,000	31	8.9	87	21.1	118	15.5
$10,000 but under $25,000	8	2.3	32	7.8	40	5.3
$25,000 but under $100,000	0	—	33	8.0	33	4.3
Over $100,000	0	—	9	2.2	9	1.2
Moderate (no figures available)	8	2.3	2	.5	10	1.3
Considerable (no figures available)	3	.9	9	2.2	12	1.6
Large	5	1.4	28	6.8	33	4.3
No data as to loss	6	1.7	5	1.2	11	1.4
Total Fires	348	100.0	412	100.0	760	100.0

Further analysis of 367 fires in the N.F.P.A. records where definite loss figures are reported indicates an average loss per fire of $1340 for fires in sprinklered bakeries and $21,820 for fires in bakeries not so equipped.

Comparison of Losses—Sprinklered and Unsprinklered Bakeries.

Loss	Sprinklered Bakeries Fires	Total Loss	Loss Per Fire	Unsprinklered Bakeries Fires	Total Loss	Loss Per Fire
Loss under $1000.....	131	$35,220	$269	36	$17,496	$486
Loss $1000 to $4999.....	28	46,708	1,670	59	140,511	2,381
Loss $5000 to $9999.....	3	20,257	6,752	28	199,420	7,132
Loss $10,000 to $24,999..	8	125,500	15,687	32	496,989	15,539
Loss $25,000 to $49,999..	0	—	—	19	673,514	35,447
Loss $50,000 to $99,999..	0	—	—	14	906,492	57,607
Over $100,000	0	—	—	9	1,896,118	210,680
Total Fires of Known Loss	170	$227,685	$1,340	197	$4,330,540	$21,820

The relation of loss incurred to values involved is indicated by the following statistics furnished by the Fire Marshal's Departments of the States of Wisconsin and Indiana.

Bakery Fires and Losses—State of Wisconsin.

Year	No. of Fires	Values Involved	Loss
1928.....	12	$260,075	$32,190
1929.....	18	229,400	24,980
1930.....	12	154,400	12,340
1931.....	5	81,000	2,000
1932.....	6	65,000	8,375
Total.....	53	$789,875	$79,885

Bakery Fires and Losses—State of Indiana.

Year	No. Fires	Buildings Value	Buildings Loss	Contents Value	Contents Loss
1925.....	12	$180,200	$10,640	$61,000	$9,363
1926.....	8	118,300	6,413	110,900	7,607
1928.....	6	40,500	1,400	11,800	1,702
1931.....	13	139,100	2,604	83,200	1,333
Total...	39	$478,100	$21,057	$266,900	$20,005

The next tables show the causes of bakery fires. One has been prepared from N.F.P.A. records, while the other two give similar figures for the State of Massachusetts and the City of Philadelphia. These data from separate sources, compiled on different bases, appear to agree as to the relative importance of major causes.

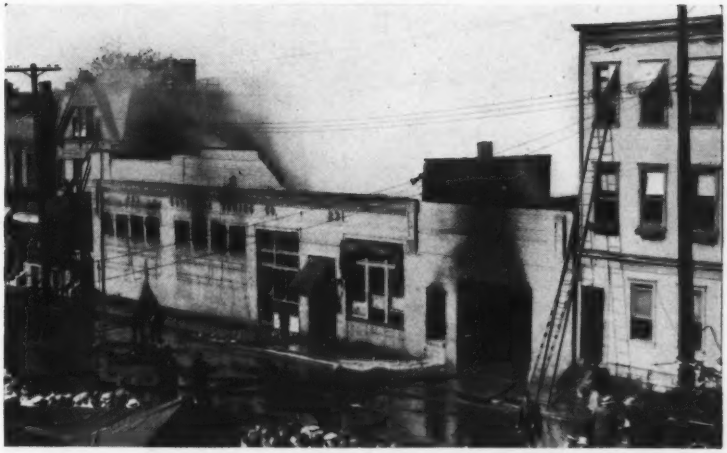
In the main table, made up from N.F.P.A. records, the data have been classified in such a way as to bring out the hazard of baking ovens, which is of primary consideration in bakery occupancies. In the supplementary discussion of the principal fire causes more detailed information relative to oven fires has been included.

The tables of fire causes indicate that special hazard and common causes are about equal as factors responsible for bakery fires. In the present study, special hazard causes were responsible for 47.2% of the fires for which the

Bakery Fire Causes.

N.F.P.A. Records, 1900-1933.

Special Hazard Causes		No. Fires	Per Cent of Known Causes
Oven Causes			
Overheated oven ignited combustible material	112		17.4
Defective oven	25		3.9
Oven explosion	15		2.3
Miscellaneous oven fires	26		4.0
Total Oven Causes		178	27.6
Special Hazard Causes Other Than Ovens			
Fat or grease boiled over or otherwise ignited	65		10.1
Spontaneous ignition of hot crackers	12		1.9
Woodwork ignited from hot stove	10		1.5
Ignition of grease in vent pipe	5		.8
Defective overheated stove	3		.5
Wax paper ignited by gas-heated bread wrapper	3		.5
Sparks from ice cream cone machine	3		.5
Spontaneous ignition, sugar or flour bags	3		.5
Miscellaneous special hazard causes	22		3.3
Special Hazard Causes Other Than Ovens		126	19.6
Total Special Hazard Causes		304	47.2
Common Causes			
Smoking—matches	72		11.1
Electrical causes	59		9.2
Spontaneous ignition, oily material	25		3.9
Overheated flue or stack	19		3.0
Defective flue or chimney	18		2.8
Ignition of soot in chimney	17		2.6
Hot ashes and coals	16		2.5
Rubbish or litter, unknown	14		2.2
Leaking gas ignited	11		1.7
Combustible material too near boiler or furnace	8		1.2
Defective or faulty operation of oil burner	8		1.2
Short circuit in automobile	7		1.1
Sparks on wooden shingle roofs	7		1.1
Careless use of acetylene torch	6		1.0
Overheated furnace	6		1.0
Miscellaneous known causes	32		5.0
Total Common Causes		325	50.6
Exposure		9	1.4
Incendiary		5	.8
Total Known Causes		643	100.0
Unknown		117	
Total Number of Fires		760	



Fire Engineering.

Plant of the Duquesne Baking Co., Pittsburgh, following a disastrous fire which swept through it on September 10, 1930. Attempts on the part of employees to extinguish the fire resulted in a delayed alarm and the entire building was involved when the fire department arrived.

cause is reasonably well known. This compares with 50.2% in the previous fire record for this occupancy (QUARTERLY, Vol 16, No. 1, July, 1922).

Causes of Bakery Fires, 1923-1932.

State of Massachusetts.	No. Fires
Smoking—matches	58
Overheated Cooking or Heating Equipment	30
Ignition of Grease on Stoves	21
Electrical Causes	16
Defective Chimneys	16
Heating or Lighting Equipment Igniting Merchandise	15
Spontaneous Ignition	8
Hot Ashes	7
Sparks from Stoves, Ovens or Furnaces	7
Defective Heating Equipment	4
Ignition of Volatile Flammable Liquids	4
Fireworks	4
Oil Burning Equipment	3
Ignition of Soot	3
Miscellaneous Known Causes	16
Unknown	5
Not Stated (1923 causes not classified)	41
Total	258

City of Philadelphia.	No. Fires
Smoking—matches	50
Ovens	40
Ignition of Fat, Lard or Grease	25
Defective Flues	25
Foul Chimneys	13
Electrical Causes	13
Sparks from Chimneys	12
Rubbish or Sweepings	8
Heaters (coal)	7
Hot Ashes and Coals	5
Oil Burners	5
Miscellaneous Known Causes	23
Unknown	57
Total	283

Factory Mutual Record.

Damage caused by the explosion of a bakery oven in Wilmington, Delaware. Six persons were seriously injured—the loss was estimated at $50,000.

Oven Causes.

Fires incidental to bakery ovens lead the list of special hazard causes with 178 fires. This obvious fire hazard apparently continues to be neglected, as is indicated by the predominance of fires from overheated ovens, defective ovens, ignition of unprotected woodwork near ovens, etc. Proper installation of the bake ovens would eliminate many of these fires.

		No. Fires
Overheated Oven Ignited Combustible Material		112
Overheated bake oven	54	
Overheated oven ignited wood floor above	16	
Combustible material on top of oven ignited	17	
Heat from oven ignited woodwork	9	
Heat from oven ignited floor beneath	13	
Combustible material under oven ignited	2	
Combustible material at side of oven ignited	1	
Defective Oven		25
Oven Explosions		15
Explosion of accumulated gas in gas-fired oven	7	
Explosion due to faulty gas valve	1	
Explosion, gas-fired oven	1	
Explosion, oil-fired oven	1	
Explosion of coal gas in flue	1	
Explosion due to clogged flue	1	
Explosion, exact cause not known	3	
Miscellaneous Oven Fires		26
Back-fire in oven	3	
Sparks from oven	6	
Overloaded circuit for electric oven	1	
Pretzels piled up on conveyor and flash fire resulted	2	
Heat from open oven door ignited combustibles	2	
Defective oil burner under oven	3	
Short circuit of electric igniter on gas-fired oven	1	
Heat from oven ignited matzoths in conveyor	1	
Loose connection on control board of electric oven	1	
Accidental manipulation of fuel oil valve	1	
Grease pot ignited from near-by oven	2	
Faulty operation of conveyor permitted ignition of material	3	
Total Oven Fires		178

Special Hazard Causes Other Than Ovens.

Other special hazard causes account for 126 fires. Of these the ignition of grease predominates, accounting for ten per cent of all bakery fires of known origin. Most of the grease fires were entirely due to carelessness in permitting fat or grease to boil over during cooking operations. Twenty-five of the grease fires were specifically chargeable to the ignition of fat while frying doughnuts.

The fires attributed to the spontaneous ignition of hot crackers occurred when hot or charred crackers were packed with other crackers and fire broke out later. The losses from such fires were, for the most part, insignificant.

With the exception of those classed as "miscellaneous" the other special hazard causes need no explanation. The "miscellaneous" class includes a variety of causes responsible for two or less fires each. These include such items as friction in sugar grinder, flour dust ignited by open flame, hot pan ignited woodwork, explosion gasoline stove, etc.

Common Causes.

Smoking—matches, as in so many other classes of occupancy, is the principal cause of fires listed under common causes, though it might be expected that smoking would be restricted where foodstuffs are handled. The cleanliness which should be prevalent in a bakery ought to lessen the probability of fires from this cause as well as fires attributable to rubbish and litter.

Fires of electrical origin in connection with electrically heated ovens and similar equipment have been included in the tables of special hazard causes. The following tabulation covers fires due to lighting and power equipment not specifically identified with special hazard equipment or processes.

	No. Fires
Defective wiring	17
Short circuit—wiring	10
Short circuit—motor	7
Overheated motor	4
Short circuit—switch	3
Defective wiring—motor	2
Defective motor	2
Overloaded circuit	2
Overloaded power line	2
Lightning burn-out	2
Electric light left in flour bin	2
Defective switch	2
Defective insulation	1
Spark from motor	1
Flat iron left in circuit	1
Fuse at coffee grinder blew out	1

Little need be said of oily material as a fire hazard. Its presence in bakeries seems entirely unjustified, and fires from this cause may well be regarded as strictly preventable.

The common hazards of defective or overheated chimneys, together with the ignition of soot in chimneys and hot ashes and/or coals account for seventy fires. No attempt has been made to segregate these into common and special hazards fires, as the same chimney may serve both an oven and a heating plant. Special hazards so they have been grouped with the former

Fire Engineering.

A typical exposure fire in a large city block was responsible for considerable damage to the bakery shown at the left of this picture. The fire had its origin in the building immediately adjoining the bakery.

class, although some of them no doubt occurred in connection with baking operations.

Other common hazard causes listed in the table are for the most part self-explanatory. The thirty-two fires classified as miscellaneous were fires from various causes common to any occupancy and have not been listed.

Complete data as to the method of discovery of the fires in the record were not available. However, it has been possible to make a general summary as follows:

Method of Discovery	Sprinklered Fires		Unsprinklered Fires		Total	
	No.	%	No.	%	No.	%
Occupants or employees	153	48.6	90	43.2	243	46.4
Outsiders	26	8.2	91	43.7	117	22.4
Sprinkler alarm	68	21.6	0	—	68	13.0
Watchmen	39	12.4	20	9.7	59	11.3
Sprinkler supervisory system	13	4.1	0	—	13	2.5
Employee and sprinkler alarm	6	1.9	0	—	6	1.1
Watchman and sprinkler alarm	6	1.9	0	—	6	1.1
Explosion	0	—	7	3.4	7	1.4
Thermostats	4	1.3	0	—	4	.8
Total	315	100.0	208	100.0	523	100.0
No data as to discovery	33		204		237	
Total	348		412		760	

As indicated by the above table thirteen fires are definitely known to have been discovered and the alarm transmitted by means of central station supervisory service. With one exception all of these alarms were promptly retransmitted to the fire department by the central station operator. In the one exception a water flow alarm was received by the central station, who dispatched a runner at once, but (as was customary in this particular city) did not notify the fire department. In three instances other alarms were transmitted in addition to the water flow alarms, one by a watchman from an auxiliary box, one by an employee over the telephone and the other by an outsider through a city fire alarm box.

Ten of these fires occurred between 7 P.M. and 7 A.M., and eight of them while the plant was not in operation. Seven fires occurred in plants where watchmen were employed and it is significant that in six of these instances the watchman failed to discover the fire and the supervisory system alone was responsible for the transmission of the alarm. In one plant where the fire was not discovered by a watchman there were four watchmen employed.

With one exception the losses in plants having central station supervision were relatively small. The one exception was the fire previously mentioned where a single runner was dispatched. In order to shut off the water it was necessary first to go to the fourth floor and ascertain that the fire was out, then go to the basement and close the main gate valve. It is said that water flowed from one sprinkler for twenty-two minutes before the valve was closed.

Four fires were discovered by the operation of thermostats. A brief summary of these fires follows:

S-7813. When a box of sweepings placed too close to the bake oven ignited, one sprinkler opened and extinguished the fire and one thermostat operated and notified the fire department. The sprinkler alarm valve failed to operate, due to dust on the contact points, and the watchman failed to discover the fire, the arrival of the fire department being his first notification that a fire was in progress. The loss was slight.

S-17622. When a fire occurred in a large wholesale bakery at 3:39 A.M., sprinklers operated and a thermostat and watchman transmitted alarms to the fire department. The local sprinkler alarm also operated. The loss to the building and contents was slight.

S-28494. When fire occurred at 2:15 A.M. in a bakery the fire department was summoned by the operation of 200-degree thermostats and arrived in time to extinguish fire before near-by 286-degree sprinkler heads could operate. No loss.

S-59089. Fire occurred from the overflow of oil from oil burner under bake ovens. One sprinkler operated and extinguished fire. Fire department was notified by operation of automatic fire alarm system with which building was equipped.

Sprinkler Fire Record.

An analysis of the N.F.P.A. fire records indicates that there have been 348 fires reported in bakery property equipped with automatic sprinklers. Included in this number, however, are 96 fires where the fire was extinguished before the heat was sufficient to cause the sprinklers to operate, and these fires are not included in this analysis.

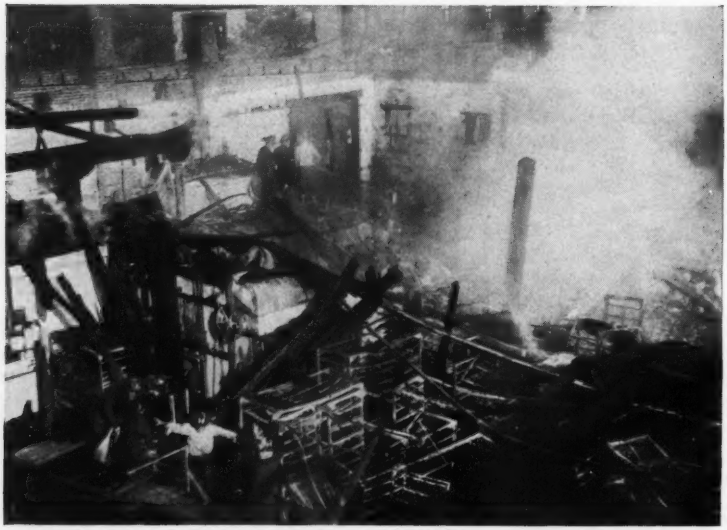
This picture shows a large gas-fired oven in a pie bakery wrecked by an explosion. The oven attendant was seriously injured. The explosion occurred when the attendant tried to relight the oven after the flame at the burners became extinguished and unburned gas had accumulated in the oven.

This record indicates that automatic sprinklers are highly efficient in this class of property and for the most part fires were extinguished by the operation of ten heads or less. Of the total number of fires in which sprinklers were a factor there were only eight in which the operation of the sprinkler system was unsatisfactory, making a total of 244 fires or 96.9%, where the operation of sprinklers was satisfactory. This compares favorably with a general average of 96.0% for all classes of occupancy.

Efficiency of Automatic Sprinklers in Bakeries.

It is customary to classify efficiency in three general divisions, as shown by the table which follows. The reports state whether fire was "extinguished" (or practically extinguished) by the sprinklers; "held in check," which generally means that hand chemicals, hose streams or other fire protection were used to aid the sprinklers; and "unsatisfactory," where the sprinklers were not effective and did not properly control the fire. The first two divisions are generally considered as satisfactory control by sprinklers, and the distinction between "extinguished" and "held in check" is not clearly marked, representing merely the opinion of the one who made the report.

	Bakery Fires		All Classes	
	No. Fires	Per Cent	No. Fires	Per Cent
Extinguished fire	194	77.1	37,134	69.5
Held fire in check	50	19.8	14,123	26.5
Total Satisfactory Control	244	96.9	51,257	96.0
Unsatisfactory	8	3.1	2,166	4.0
Total Sprinklers Operating	252	100.0	53,423	100.0
Sprinklers not a factor	96			
Total	348			



Fire Engineering.

Interior view of the Duquesne Baking Co. plant, showing complete destruction of the contents and damage to bake ovens.

The fires noted as unsatisfactory are as follows:

S-10465. Nine sprinkler heads in immediate fire zone failed to operate. Subsequent test showed eight of them to be defective. Fire was extinguished with slight loss by use of soda-acid extinguishers.

S-10707. Two sprinklers opened promptly, but were of no value as heads were clogged with gravel. The fire was extinguished with small loss by employees with soda-acid extinguishers.

S-29076. Sprinklers were shut off by night foreman before fire was extinguished. They were ordered on again and with hose streams used by the fire department extinguished the fire. Had the sprinklers been left on it would probably have not been necessary to use the hose streams.

S-36957. Fire of unknown origin severely damaged bakery building and contents. The building was fully equipped with automatic sprinklers and after the fire all but 45 of the 227 heads were found fused. Fire department officers noticed that no sprinklers appeared to have been operating during the fire and the water flow alarm did not operate. It seems probable that the sprinkler system was shut off.

S-42473. Fire occurred in garage section of bakery and was discovered by watchman who apparently became very excited and lost his reasoning power. He summoned the fire department by telephone and then shut off the sprinklers before the arrival of the firemen. All of the 77 heads in the room opened, but were of no value in holding the fire. The loss was between $2500 and $3000.

S-42182. The sprinklers in the section where the fire started failed to hold the fire because water apparently never reached them. Investigation after the fire seemed to point to some tampering with the system, although no evidence of incendiarism could be

obtained. Sprinklers in other areas prevented the spread of the fire to the main building. The loss was considerable.

S-47808. Fire originated between metal ceiling of first floor and second floor and spread through partitions to third floor. Due to location of fire, sprinklers were ineffective until heat radiated through the metal ceiling, when three sprinklers operated and prevented spread of fire on first floor. The loss was considerable.

S-51470. Fire, due to an explosion of an automatic oil burner under the boilers, swept through the basement and first floor of a bakery. It was apparent from the effects of the fire that the sprinkler system covering these sections was not operative. Certain sprinklers which were opened from the heat were still covered with dust, showing that no water had been discharged. The dry pipe system covering the second and third floors apparently operated properly.

It is believed that the sprinkler system covering the basement and first floor was shut off at the time of the fire. It had probably been shut off because the valve had tripped and could not be restored to dry pipe service, as no current was available to operate the air pump during the two-weeks' period preceding the fire.

Number of Sprinklers Opened.

The next table gives the number of fires extinguished by one sprinkler, one and two combined, three or less, etc., and the percentage of all bakery fires. It also is divided into wet and dry pipe systems.

The last column gives percentages for all classes of property and a comparison of the bakery percentages in the next to the last column, and the percentages for all classes in the last column gives some idea of the comparative effectiveness of sprinklers in bakeries to control fires promptly and with small loss.

It will be noted that in bakeries 47.7% of the fires are controlled by one sprinkler, as compared to 34.3% for all classes. Similarly, 91% in bakeries are controlled by five sprinklers or less, as compared with 72.5% for all classes. Approximately 95% of all bakery fires are controlled by 10 sprinklers or less.

Number of Sprinklers Opened.

No. Sprinklers	Bakery Fires		All Classes
	No.	Per Cent	Percentages
1	112	47.7	34.3
2 or less	163	69.5	49.8
3 or less	189	80.4	61.3
4 or less	208	88.6	68.3
5 or less	214	91.0	72.5
10 or less	223	94.9	83.8
11 to 25 inclusive	5	2.1	
26 to 50 inclusive	4	1.7	
Over 50	3	1.3	
Total (data available)	235	100.0	
No data	17		
Total Fires	252		

Comparison of Wet and Dry Systems.

	Wet	Per Cent	Dry	Per Cent	No Data	Total	Per Cent
Extinguished Fire	145	77.2	37	78.8	12	194	77.1
Held Fire in Check.....	37	19.7	9	19.1	4	50	19.8
Unsatisfactory	6	3.1	1	2.1	1	8	3.1
Total.....	188	100.0	47	100.0	17	252	100.0

Losses in Sprinklered Fires.

The amount of loss is generally noted on fire reports, and these notations or estimates are tabulated below. "No claim" or "small loss" is given in the large majority of cases, no claim referring to insurance, and small loss being used where not serious in the opinion of the writer of the report. In a few cases the wording "moderate," "considerable" or "large" is used.

The following table presents a brief summary of losses in bakery property protected by automatic sprinklers. More detailed information may be found under "Analysis of Bakery Losses" in the first part of this fire record. The loss estimates which follow are divided into four items. The average loss under item 1 is undoubtedly very small, probably not in excess of one or two hundred dollars. Item 2 includes losses noted as less than $5000. The average of losses under Item 2 is $515. Losses in excess of $10,000 are noted after the table, as are also those reported as "large."

Amount of Loss	No. Fires	Per Cent
1. No claim or small.....	156	44.8
2. Under $1000	131	37.6
$1000 to $4999.....	28	8.0
3. Over $5000	11	3.2
4. No data as to exact amount of loss.....	22	6.4
	348	100.0

This table includes all fires in sprinklered property, whether sprinklers were a factor or not.

Fires Involving Loss of $10,000 or Over.

Fire No. S-27801. Loss given as $10,000. (Sprinklers practically extinguished fire. Loss due largely to water).

Fire No. S-31631. Loss estimated at 15,000. (No sprinklers in area where fire occurred. Approximately $14,500 of loss, due to water from hose streams).

Fire No. S-36957. Loss large, but no estimate. (Sprinklers shut off.)

Fire No. S-40493. Loss estimated at $20,000. (Oven explosion.)

Fire No. S-43622. Loss estimated at $12,000. (Oven explosion.)

Fire No. S-44976. Loss, $14,624. (Loss largely due to smoke.)

Fire No. S-45539. Loss, $19,825. (Exposure fire caused sprinklers to operate. Water from sprinklers, hose streams and rain was responsible for $9800 of the total loss).

Fire No. S-56102. Loss estimated at $17,500. (No sprinklers in section where fire started.)

Fires in Which There Was Loss of Life.

First Quarter, 1934.

Since the publication of the January QUARTERLY, the N.F.P.A. Department of Fire Record has received from various sources 230 reports of fires in which there has been loss of life. A total of 394 lives were lost in fires included in this tabulation.

Six disasters in which more than five lives were lost occurred during the period covered by this record as follows:

January 15, 1934. Chavez, N. M. A family of seven, including the father, mother and five children, were fatally burned when their home was destroyed by fire.

February 9, 1934. Unison, Va. Eight negro children sleeping in the loft of their log cabin home were trapped by an early morning fire. Another child jumped from a window and escaped.

Loss of Life Fires, January-March, 1934.*

This is a typical rather than a complete record, presented to show the conditions under which loss of life occurs that they may be known and guarded against. The total loss of life by fire in the United States is estimated at 10,000 annually.

Class of Fire	No. Fires	Men	Women	Children	No data	Total
Airplane fires	7	10	1	0	0	11
Apartments, hotels, lodgings, tenements, etc...	29	40	14	16	2	72
Automobile fires	8	11	4	2	0	17
Barns and stables	2	2	0	0	0	2
Dwellings—Rural	81	35	35	76	0	146
Dwellings—Urban	67	31	36	11	0	78
Fireworks and powder factories	1	4	0	0	0	4
Forest or brush fires	1	1	0	0	0	1
Garages	2	2	0	0	0	2
Gasoline filling station	2	3	0	0	0	3
Industrial occupancies	1	1	0	0	0	1
Institutions	3	1	10	1	0	12
Mercantile occupancies	4	5	0	0	1	6
Mining property	2	8	0	0	0	8
Motion picture theatres	2	2	1	1	0	4
Oil refineries and distributing stations	2	1	1	0	0	2
Other buildings	3	3	1	0	0	4
Outside of buildings	6	2	1	3	0	6
Response to alarms	4	10	0	0	0	10
Ships and boats	1	0	2	0	0	2
No data	2	1	0	0	2	3
	230	173	106	110	5	394

*This table is made up from those reports received by the Department of Fire Record between January 1 and March 31, 1934. A few of the fires included herein occurred prior to January 1, but were not reported until subsequent to that date.

Causes of Loss of Life, January-March, 1934.

Fatalities classified according to the immediate cause of the loss of life rather than according to the cause of the fire.

Causes	Men	Women	Children	No data	Total
Airplane fires	10	1	0	0	11
Automobile fires	11	4	2	0	17
Children alone in house	0	0	13	0	13
Children and matches	0	0	4	0	4
Cleaning with gasoline	1	1	0	0	2
Clothing ignited:					
Candle	0	1	0	0	1
Electric heater	2	5	4	0	11
Furnaces or stoves	0	1	0	0	1
Match	0	1	0	0	1
Open flame, grate, or heater	2	6	1	0	9
Rubbish fire	0	0	2	0	2
No data	0	3	0	0	3
Escaping from fire—jumped	1	0	1	0	2
Explosion or flash fire:					
Frozen water coil in stove	0	1	0	0	1
Gas	1	0	2	0	3
Gas stove	1	0	0	0	1
Gasoline stove	2	3	0	0	5
Gasoline tank on boat	0	2	0	0	2
Gasoline vapor	2	0	1	0	3
Kerosene lamp, stove, or heater	3	10	1	0	14
Manhole	1	0	0	0	1
Mining property	8	0	0	0	8
Oil on stove	2	0	0	0	2
Oil refinery	1	1	0	0	2
Powder plant	4	0	0	0	4
Transformer	1	0	0	0	1
Unknown	1	0	0	1	2
Fire fighting	9	1	0	0	10
Forest or brush fire fighting	1	0	0	0	1
Gasoline used to start fire	0	1	2	2	5
Ignition of flammable liquids or vapors	5	6	4	0	15
Kerosene used to start fire	3	8	7	0	18
Overcome by smoke—suffocation	8	8	2	2	20
Overexertion or excitement	2	0	0	0	2
Re-entering burning buildings	4	1	0	0	5
Response to alarms	10	0	0	0	10
Shock or after effects of fire	0	1	0	0	1
Smoking	10	1	0	0	11
Trapped in burning buildings	64	40	64	0	168
No data	2	0	0	0	2
Total	173	106	110	5	394

February 17, 1934. New York, N. Y. Eight persons, belonging to two families, were burned to death when a fire starting in the basement swept through a tenement house, burning through the roof.

February 20, 1934. Brookville, Pa. Ten aged women were burned to death when a frame infirmary building, part of a home for widows of Civil War veterans, was swept by fire during one of the coldest nights of the winter. A nurse on duty saved five other old women also quartered in the building.

February 26, 1934. Utica, N. Y. Six men were trapped and burned to death, and another was severely injured by jumping, when fire swept through a four-story hotel. The blaze gained great headway before it was discovered.

March 24, 1934. Lynchburg, Va. Nineteen lives lost. See page 301.

Typical Loss of Life Fires.

Children Alone in House.

L-2349. PARAGOULD, ARK. JANUARY 3, 1934. Three small children were burned to death when fire destroyed the two-room farmhouse in which they had been left alone.

L-2348. DAUPHIN, MAN. JANUARY 6, 1934. Three small children left asleep in their cribs on the second floor were burned to death, when fire presumably started by a defective chimney destroyed their home while their mother was visiting a neighbor.

L-2330. HAGERSTOWN, MD. FEBRUARY 28, 1934. A baby was fatally burned in a crib when his blanket caught fire from a stove. The water pipes in the house were frozen and the mother left the child alone while she went out for water.

Children and Matches.

L-2342. MONTREAL, P. Q. FEBRUARY, 2, 1934. While playing with her six-year-old brother a four-year-old girl was burned to death when her clothing ignited from a match which the boy struck while pretending to light the kitchen stove. Before her mother could reach her the little girl was fatally burned.

Explosions of Gasoline Stoves.

H-37460. ANDALUSIA, ALA. JANUARY 27, 1934. A young man was burned to death when the tank of a gasoline stove in his father's store exploded, presumably while he was pumping up air pressure. The stove was of a non-standard type, but was not known to have given previous trouble.

L-2338. MANCHESTER, N. H. FEBRUARY 9, 1934. A woman was fatally burned and her husband and another man were seriously burned when a gasoline stove exploded. The stove was being cleaned in order to produce more heat, when it exploded and spattered blazing gasoline on the victims.

L-2339. SPRINGFIELD, MASS. FEBRUARY 9, 1934. A young woman was fatally burned and her mother badly burned by an explosion of a gasoline stove. The stove was being lighted when suddenly flames shot out and ignited the younger woman's clothing.

Gasoline Used to Start Fire.

L-2347. LAWRENCE TOWNSHIP, N. J. JANUARY 7, 1934. Two small girls were burned to death and two men were badly burned when the children's mother used gasoline mistaken for kerosene to revive a fire in the kitchen stove, causing an explosion.

Kerosene Used to Start Fire.

L-2350. CRANSTON, R. I. DECEMBER 26, 1933. A young woman, mother of two children, died of burns received when she tried to kindle her kitchen fire with kerosene. The flash ignited her clothing and she was burned from head to feet.

L-2343. NORTHAMPTON, MASS. JANUARY 28, 1934. A man was fatally burned while putting kerosene on a fire in the kitchen stove of his home. His wife and daughter were seriously injured by glass when they escaped through a window.

Ignition of Flammable Liquids or Vapors.

L-2344. SHAWINIGAN FALLS, P. Q. JANUARY 24, 1934. Being unable to obtain alcohol for a lamp a man attempted to fill the lamp with gasoline. Vapor ignited from a lighted candle and the fire spread to the man's clothing. He ran outside and rolled in the snow, but was unable to prevent fatal injuries.

Overcome by Smoke—Suffocation.

L-2341. ALBANY, N. Y. FEBRUARY 3, 1934. Overcome by smoke while trying to reach his daughter, a man died in an early morning fire in his home. Unknown to him his daughter and other members of the family had escaped.

L-2331. SAVANNAH, GA. FEBRUARY 19, 1934. Heat from a fire which was entirely confined to the first floor of her house cost the life of a young woman on the second floor. Although not touched by flames and promptly carried from the house by firemen from a near-by station, she died as a result of burns caused by terrific heat which came up the stairs from the floor below. It is thought that the victim delayed her escape to save her belongings, as a woman living with her escaped down the stairs safely.

Re-entering Burning Building.

L-2334. FLINTSTONE, MD. FEBRUARY 13, 1934. A woman died in a hospital of burns she received when fire destroyed her home. She had escaped from the house, but was fatally burned when she returned to save some possessions.

Trapped in Burning Building.

H-37030. MT. VERNON, N. Y. DECEMBER 31, 1933. Fourteen persons were injured, one child fatally, when a fire swept a motion picture theatre during a performance. Fire started near the screen and spread rapidly into the auditorium. There was some confusion, due to mistaking of a washroom door for an exit, and due to difficulty in opening several of the exit doors. The one fatality was a five-year-old child who had been with her family in a front row. A policeman, who found the child and carried her out, was badly burned.

Annual Sprinkler Tables.

Statistics of Fires in Properties Having Automatic Sprinkler Protection.

NOTE.—These tabulations are made at the close of each year with the object of furnishing a basis upon which the virtues of the automatic sprinkler as an extinguishing agent can be estimated.

Section I is devoted to fires in which the behavior of sprinklers was, for the reasons given, unsatisfactory.

Section II is a statistical record of all reports of sprinkler fires in the files of the Association upon which the information obtained is sufficiently complete for statistical purposes.

In these tables the results of the current year ending February 1, 1934, are given and these are compared with the results of the total thirty-seven year record ending at that time.

The annual sprinkler tabulation is published this year for the thirty-eighth consecutive year. The tables which follow show the actual fire experience with automatic sprinkler equipments in sixty-five thousand nine hundred fires. This is not intended as a complete statistical report of fires in sprinklered properties; it includes only those fires reported to the N.F.P.A. Department of Fire Record in sufficient detail to give the data necessary for the tables. While the fires included in this tabulation are probably only a fraction of the total number of fires occurring in buildings under sprinkler protection, with a total of 65,900 fires in the record and current reports being received at an average rate of three thousand annually, there can be no doubt that this summary as a whole is completely representative.

An exception to this statement may be made in the case of the detailed records of experience in some occupancies where only a comparatively small number of fires are reported. In order to maintain the continuity of the tables from year to year it is necessary to have every occupancy classification appear, even though there be but one sprinklered fire reported. It is obvious, however, that conclusions should not be drawn as to the effectiveness of sprinklers in an occupancy where the number of fires reported is so small that the figures may be distorted by some one unusual fire.

The classifications "extinguished fire" and "held fire in check" appearing in the several tables may both be considered as satisfactory performance. The distinction between these two classifications is necessarily more or less arbitrary, depending upon the judgment of the original inspector. The great majority of the fires in the "held in check" columns are instances where hose streams or other equipment were used to extinguish fire in spaces which water from the sprinklers did not reach because of obstructions to distribution, concealed spaces or unsprinklered portions, but where sprinklers functioned satisfactorily in preventing the spread of fire.

In preparing these tables it is the fixed policy of the Department of Fire Record never to give the sprinklers the benefit of the doubt. In cases where there is question as to whether a given fire should be classified as "Held in Check" or "Unsatisfactory," it is always placed in the "Unsatisfactory" column. The tables thus give a very conservative picture of the efficiency of sprinklers. Likewise it should be noted that there are doubtless a large number of fires annually which are extinguished by one or two sprinkler heads where no claim for loss is made and where no report reaches the Department of Fire Record. If it were possible to include all such fires in the tables the sprinkler efficiency would approach much nearer to one hundred per cent.

The record of sprinkler efficiency for 1933-1934 is 97.4 per cent, the highest recorded in any year since 1897. This record is presumably due in part to the same causes which have operated to reduce the national fire losses for 1933. Increased care in sprinkler maintenance is also reflected. When reviewing the detailed tabulation of unsatisfactory sprinkler performance it should be noted that these fires represent a small percentage of the total number included in the record and that they are compiled not with the thought of emphasizing the relatively few cases where sprinkler operation is unsatisfactory, but pointing the way toward better performance by indicating those factors which should receive attention.

The tables presented this year follow the same general plan and arrangement as in previous years. The following changes in occupancy classification have been made during the past year:

Hospitals (fires formerly classified as Institutions)
Institutions (decreased by fires reclassified as Hospitals)
Photo Camera and Film Mfg. (formerly Photographic Establishments)
Photo Engraving and Studios (formerly Photographic Establishments)
Photographic Establishments (divided into Photo Camera and Film Mfg., and Photo Engraving and Studios)
Tobacco Warehouses (fires formerly classed as Warehouses)
Warehouses (decreased by adjustments made to correct classifications)

The total number of sprinklered fire reports received during the past year was 2900. This total includes 575 fires in which the sprinklers were not a factor. This latter classification includes fires occurring in unsprinklered portions of buildings which did not extend to the sprinklered portions, or fires occurring in sprinklered portions which were discovered and extinguished by other means before there was sufficient heat to open sprinklers. The total number of fires since 1897 in sprinklered properties where sprinklers were not a factor is 12,477.

The present tables include nineteen fires in properties protected by thermostatically operated open head systems. These are separately listed in Section II, Tables 2 and 3.

SECTION I.

Summary of Unsatisfactory Sprinkler Fires.

	1933-1934 No. of Fires	1933-1934 Per Cent	1897-1934 incl. No. of Fires	1897-1934 incl. Per Cent
Water shut off	22	33.3	692	31.9
Generally defective equipment	3	4.5	391	18.0
Unsprinklered portions	7	10.7		
Defective water supply or supplies	7	10.7	194	8.9
Sprinkler system crippled due to freezing	5	7.6	59	2.7
Slow operation of dry system or defective valve	1	1.5	67	3.2
Slow or defective operation of high test heads	2	3.0	27	1.2
Faulty building construction, concealed spaces, vertical openings, etc.	1	1.5	107	4.9
Obstruction to distribution	3	4.5	131	6.1
Hazard of occupancy too severe for average sprinkler equipment	4	6.1	125	5.9
Explosion crippled sprinkler system	2	3.0	104	4.8
Exposure or conflagration	3	4.5	87	4.0
Plugged heads and piping (included with Miscellaneous prior to 1921)	5	7.6	44	2.0
Miscellaneous	1	1.5	136	6.4
Total	66	100.0	2166	100.0

Fires in Which Failure Was Due to Water Shut Off Sprinklers.

	1933-1934 No. of Fires	1897-1934 No. of Fires
Water shut off for unknown reason, neglect or carelessness	6	210
Water shut off before fire was out, or fire rekindled	3	121
Water shut off due to accidents or repairs	1	106
Water shut off to prevent freezing	4	157
Water shut off, probably incendiary	6	31
Water shut off, leaky dry system	2	17
Water shut off, defective gate valve	—	9
Water shut off, miscellaneous	—	42
Total	22	692

SECTION II.

Annual Revision of Sprinkler Fire Tables.

The following tables are a summary of fires occurring in properties equipped with automatic sprinklers. The total number of such fires reported during the past year was 2900, which includes 475 fires where no sprinklers were opened. A number of reports were received in which the data were incomplete and these are not included in this tabulation. It may be noted that the total number of fires does not agree throughout all the tables. This is because some of the reports of fires in prior years were not sufficiently complete to include in all the tables.

Table No. 1—Effect of Sprinklers.

	1933-1934 No. of Fires	%	1897-1934 No. of Fires	%
Practically or entirely extinguished...	1861	76.9	37134	69.5
Held fire in check.....	498	20.5	14123	26.5
Total Satisfactory.....	2359	97.4	51257	96.0
Unsatisfactory	66	2.6	2166	4.0
Total.....	2425		53423	

Table No. 2—Number of Sprinklers Operating.

No. of Fires, 1897-1934, inclusive

No. of Sprinklers Operating	Wet	%	Dry	%	No Data	Total	%
1	15895	38.4	1803	20.0	670	18368	34.7
2 or less.....	23592	57.0	3049	34.3	978	27619	51.9
3 or less.....	27724	64.4	3825	42.9	1158	32707	61.6
4 or less.....	30557	73.6	4466	50.1	1306	36329	68.4
5 or less.....	32265	77.6	4871	55.0	1399	38535	72.4
6 or less.....	33626	81.0	5259	59.2	1475	40360	75.8
7 or less.....	34583	83.4	5560	62.5	1521	41664	78.4
8 or less.....	35472	85.4	5809	65.3	1575	42856	80.7
9 or less.....	36068	86.8	6012	67.5	1610	43689	82.3
10 or less.....	36604	88.2	6184	69.4	1654	44441	83.6
11 or less.....	36999	89.3	6329	71.1	1674	45002	84.8
12 or less.....	37435	90.1	6518	73.2	1715	45668	86.0
13 or less.....	37692	90.8	6656	74.7	1732	46080	86.8
14 or less.....	37989	91.5	6782	76.3	1754	46525	87.6
15 or less.....	38229	92.0	6898	77.5	1770	46897	88.3
20 or less.....	39064	94.5	7267	81.6	1843	48174	90.8
25 or less.....	39557	95.4	7545	84.8	1874	48976	92.3
30 or less.....	39895	96.1	7734	86.8	1898	49527	93.3
35 or less.....	40105	96.9	7859	88.4	1915	49879	94.0
40 or less.....	40289	97.1	7969	89.5	1934	50192	94.6
50 or less.....	40517	97.5	8121	91.2	1959	50597	95.4
75 or less.....	40835	98.3	8323	93.5	1981	51139	96.3
100 or less.....	40976	98.7	8428	94.7	1991	51395	96.9
Over 100.....	431		361		40	832	
No data.....	101		97		642	840	
Open head systems	0		19		0	19	
Total.....	41508		8905		2673	53086	
Water shut off sprinklers.....						337	
Total.....						53423	

Table No. 3—Numbers of Sprinklers Operating.

No. of Sprinklers Operating	No. of Fires, 1933-1934 Wet	%	Dry	%	No Data	Total	%
1	742	41.6	104	26.3	101	947	39.0
2	334	18.8	68	17.1	27	429	17.6
3	173	9.8	31	7.8	11	215	8.9
4	99	5.6	23	5.8	11	133	5.5
5	70	3.9	11	2.8	3	84	3.5
6	49	2.8	10	2.5	4	63	2.6
7	42	2.4	20	5.0	3	65	2.7
8	39	2.2	10	2.5	5	54	2.2
9	25	1.4	10	2.5	1	36	1.5
10	27	1.5	7	1.8	1	35	1.4
11	17	1.0	4	1.0	2	23	1.0
12	29	1.6	6	1.5	2	37	1.5
13	10	.6	5	1.3	0	15	.6
14	13	.7	9	2.3	3	25	1.0
15	9	.5	1	.3	1	11	.5
16-20	24	1.4	6	1.5	6	36	1.5
21-25	19	1.1	10	2.5	0	29	1.2
26-30	8	.5	6	1.5	2	16	.7
31-35	11	.6	2	.5	2	15	.6
36-40	3	.2	6	1.5	3	12	.5
41-50	9	.5	7	1.8	5	21	.8
51-75	7	.3	3	.8	4	14	.6
76-100	3	.2	2	.5	1	6	.3
Over 100	8	.5	15	3.6	3	26	1.1
No data	7	.3	13	3.3	50	70	2.8
Open head systems	0	..	8	2.0	0	8	.4
Total	1777	100.0	397	100.0	251	2425	100.0

No. of Sprinklers Operating	No. of Fires, 1897-1934, inclusive. Wet	%	Dry	%	No Data	Total	%
1	15895	38.4	1803	20.0	670	18368	34.7
2	7697	18.8	1246	14.1	308	9251	17.4
3	4132	1.0	776	8.7	180	5088	9.6
4	2833	6.8	641	7.2	148	3622	6.8
5	1708	4.1	405	4.5	93	2206	4.1
6	1361	3.3	388	4.4	76	1825	3.4
7	957	2.3	301	3.4	46	1304	2.4
8	889	2.1	249	2.8	54	1192	2.2
9	596	1.4	203	2.3	35	834	1.6
10	536	1.3	172	1.9	44	752	1.4
11	395	.9	145	1.6	20	560	1.1
12	436	1.0	189	2.1	41	666	1.3
13	257	.6	138	1.6	17	412	.8
14	297	.7	126	1.4	22	445	.8
15	240	.6	116	1.3	16	372	.7
16-20	835	2.0	369	4.2	73	1277	2.4
21-25	493	1.2	278	3.1	31	802	1.5
26-30	338	.8	189	2.1	24	551	1.0
31-35	210	.5	125	1.4	17	352	.7
36-40	184	.4	110	1.2	19	313	.6
41-50	228	.5	152	1.7	25	405	.8
51-75	318	.8	202	2.3	22	542	1.0
76-100	141	.3	105	1.2	10	256	.5
Over 100	431	1.0	361	4.1	40	832	1.6
No data	101	.2	97	1.1	642	840	1.6
Open head systems	0	..	19	.2	0	19	..
Total	41508	100.0	8905	100.0	2673	53086	100.0
Water shut off sprinklers						337	
Total						53423	

Table No. 4—Effect of Sprinklers by Class of Occupancy.

	Extinguished Fire		Held Fire in Check		Total Satisfactory		Unsatisfactory		Total No. of Fires
	No.	%	No.	%	No.	%	No.	%	
Abrasive Works	27	73.0	8	21.6	35	94.6	2	5.4	37
Agricultural Implements	80	61.1	45	34.3	125	95.4	6	4.6	131
Airplane Factories	8	53.3	7	46.7	15	100.0	0	..	15
Airports and Hangars	2	33.3	4	66.7	6	100.0	0	..	6
Alcohol Distilleries	1	25.0	2	50.0	3	75.0	1	25.0	4
Aluminum Works	5	50.0	4	40.0	9	90.0	1	10.0	10
Amusement Places	30	83.4	3	8.3	33	91.7	3	8.3	36
Apartment Houses	148	85.6	25	14.4	173	100.0	0	..	173
Artificial Leather Mfg.	33	53.2	26	41.9	59	95.1	3	4.9	62
Asbestos Works	22	55.0	15	37.5	37	92.5	3	7.5	40
Automobile Mfg.	335	65.6	155	30.3	490	95.9	21	4.1	511
Automobile Body Mfg.	158	59.0	85	31.7	243	90.7	25	9.3	268
Automobile Paint Shops	10	77.0	3	23.0	13	100.0	0	..	13
Auto Sales and Service	37	68.5	12	22.2	49	90.7	5	9.3	54
Bag Factories	51	63.0	26	32.1	77	95.1	4	4.9	81
Bakeries	194	77.1	50	19.8	244	96.9	8	3.1	252
Basket Factories	15	83.4	2	11.1	17	95.5	1	4.5	18
Battery Mfg.	43	70.6	15	24.6	58	94.6	3	5.4	61
Bolt, Nut and Screw Works	24	57.2	15	35.8	39	93.0	3	7.0	42
Bottle Caps and Seals Mfg.	45	53.6	39	46.4	84	100.0	0	..	84
Bottling Works	9	75.0	2	16.7	11	91.7	1	8.3	12
Braid Mills	67	77.9	17	19.8	84	97.7	2	2.3	86
Brass and Copper Works	84	73.1	28	24.3	112	97.4	3	2.6	115
Breweries	5	83.4	1	16.6	6	100.0	0	..	6
Brick and Tile Works	1	100.0	0	..	1	100.0	0	..	1
Broom Factories	23	70.6	8	23.5	31	94.1	3	5.9	34
Brush Factories	33	71.8	13	28.2	46	100.0	0	..	46
Buildings Under Construction	5	62.5	3	37.5	8	100.0	0	..	8
Button Factories	78	83.8	13	14.0	91	97.8	2	2.2	93
Candle Factories	9	56.2	7	43.8	16	100.0	0	..	16
Candy Factories	246	72.6	82	24.2	328	96.8	11	3.2	339
Canneries	21	65.6	8	25.0	29	90.6	3	9.4	32
Canvas and Cotton Belting	6	60.0	4	40.0	10	100.0	0	..	10
Carbon Works	11	84.7	2	15.3	13	100.0	0	..	13
Car Houses	44	46.3	43	45.2	87	91.5	8	8.5	95
Car Works	83	61.5	47	34.8	130	96.3	5	3.7	135
Carpet and Rug Mills	215	64.7	106	31.9	321	96.6	11	3.4	332
Cement and Plaster Mills	11	64.8	3	17.6	14	82.4	3	17.6	17
Cereal Mills	43	65.1	15	22.8	58	86.9	8	13.1	66
Chemical and White Lead Works	212	62.9	102	30.3	314	93.2	23	6.8	337
Churches	1	100.0	0	..	1	100.0	0	..	1
Clock and Watch Mfg.	17	77.3	5	22.7	22	100.0	0	..	22
Clothing Mfg.	2340	85.8	363	13.3	2703	99.1	22	.9	2725
Clubs—City	29	85.3	4	11.8	33	97.1	1	2.9	34
Clubs—Country	13	68.5	6	31.5	19	100.0	0	..	19
Coal and Wood Yards	3	27.3	7	63.6	10	90.9	1	9.1	11
Cocoanut Mills	6	75.0	2	25.0	8	100.0	0	..	8
Coffee and Spice Mills	99	70.6	37	26.4	136	97.0	4	3.0	140
Coffin and Casket Mfg.	81	75.0	22	20.3	103	95.3	5	4.7	108
Cold Storage Plants	16	66.7	8	33.3	24	100.0	0	..	24
Cooperage Plants	66	60.5	31	28.4	97	88.9	12	11.1	109
Cordage Works	263	65.2	125	31.0	388	86.2	16	13.8	404
Cork Factories	31	52.6	23	39.0	54	91.6	5	8.4	59
Cotton Gins	12	63.2	5	26.3	17	89.5	2	10.5	19
Cotton Mills	6249	65.6	3161	33.2	9410	98.8	114	1.2	9524
Cotton Seed Oil Mills	45	47.9	31	33.0	76	80.9	18	19.1	94
Cotton Warehouses	249	50.1	204	41.0	453	91.1	44	8.9	497
Cutlery Mfg.	29	58.4	17	34.1	46	92.5	3	7.5	49
Dairies and Creameries	10	83.4	2	16.6	12	100.0	0	..	12

	Extinguished Fire		Held Fire in Check		Total Satisfactory		Unsatisfactory		Total No. of Fires
	No.	%	No.	%	No.	%	No.	%	
Department Stores	758	79.5	172	18.1	930	97.6	21	2.4	951
Distilleries	9	52.9	5	29.4	14	82.3	3	17.7	17
Doll Factories	86	66.1	44	33.9	130	100.0	0	..	130
Drug Mfg. and Warehouses	271	80.6	59	17.6	330	98.2	6	1.8	336
Dry Cleaning Establishments	18	62.1	11	37.9	29	100.0	0	..	29
Dry Goods Stores	391	86.0	59	12.9	450	98.9	5	1.1	455
Dwellings	1	50.0	0	..	1	50.0	1	50.0	2
Dyeing, Bleaching, Finishing	311	60.1	187	36.2	498	96.3	19	3.7	517
Electrical Appliance Mfg.	551	73.2	190	25.2	741	98.4	13	1.6	754
Electric Power and Light	8	42.0	8	42.0	16	84.0	3	16.0	19
Excelsior Factories	36	69.3	12	23.1	48	92.4	4	7.6	52
Fertilizer Plants	31	69.6	13	27.1	44	96.3	4	3.7	48
Fiber Products	15	53.5	12	42.8	27	96.3	1	3.7	28
Fireworks Plants	0	..	2	100.0	2	100.0	0	..	2
Flax and Linen Mills	50	56.7	37	42.1	87	99.0	1	1.2	88
Flour and Grist Mills	89	52.3	51	30.0	140	82.3	30	17.7	170
Forge and Smithy	29	70.8	10	14.4	39	85.2	2	14.8	41
Foundries	250	61.0	140	34.2	390	95.2	20	4.8	410
Fruit Packing	9	100.0	0	..	9	100.0	0	..	9
Fur Works	220	94.0	10	4.3	230	98.3	4	1.7	234
Furniture Factories	1062	68.3	384	24.7	1446	93.0	110	7.0	1556
Furniture Stores	138	78.4	31	17.6	169	96.0	7	4.0	176
Garages	595	71.0	224	26.7	819	97.7	19	2.3	838
Garbage Reduction Plants	3	60.0	1	20.0	4	80.0	1	20.0	5
Gas Works	3	50.0	2	33.3	5	83.3	1	16.7	6
General Stores	1	50.0	1	50.0	2	100.0	0	..	2
Glass Factories	104	60.2	51	29.5	155	89.7	18	10.3	173
Glove Factories	20	66.7	9	30.0	29	96.7	1	3.3	30
Glue Factories	10	45.5	9	40.8	19	86.3	3	13.7	22
Grain Elevators	38	40.0	31	32.7	69	72.7	26	27.3	95
Groceries	218	79.0	48	17.4	266	96.4	10	3.6	276
Gum Mfg.	9	81.8	2	18.2	11	100.0	0	..	11
Hair Works	27	79.5	7	20.5	34	100.0	0	..	34
Hardware Stores	128	82.6	24	15.5	152	98.1	3	1.9	155
Hat Factories	450	80.2	91	16.2	541	96.4	21	3.6	562
Hospitals	32	84.2	6	15.8	38	100.0	0	..	38
Hotels—Year Round	108	82.5	18	13.7	126	96.2	5	3.8	131
Hotels—Seasonal	15	62.5	8	33.3	23	95.8	1	4.2	24
Ice Cream Mfg.	7	58.4	5	41.6	12	100.0	0	..	12
Ice Houses	0	..	2	66.7	2	66.7	1	33.3	3
Ice Manufacturing	2	66.7	1	33.3	3	100.0	0	..	3
Idle and Vacant Property	47	55.3	16	18.8	63	74.1	22	25.9	85
Incandescent Lamp Works	27	67.5	13	32.5	40	100.0	0	..	40
Institutions	13	92.9	1	7.1	14	100.0	0	..	14
Insulated Wire Works	60	65.2	30	32.6	90	97.8	2	2.2	92
Jewelry Factories	211	85.1	30	12.1	241	97.2	7	2.8	248
Junk Shops	32	66.7	11	22.9	43	89.6	5	10.4	48
Knitting Mills—Cop Yarn	70	67.3	27	26.0	97	93.3	7	6.7	104
Knitting Mills—Full Process	674	68.7	276	28.2	950	96.9	31	3.1	981
Lamp Shade Factories	48	92.4	3	5.7	51	98.1	1	1.9	52
Laundries	168	74.7	51	22.2	219	96.9	6	3.1	225
Lead Pencil Factories	19	70.4	7	25.9	26	96.3	1	3.7	27
Leather Working	238	82.7	45	15.6	283	98.3	5	1.7	288
Linoleum Works	37	30.3	69	55.6	106	85.9	18	14.1	124
Linseed Oil Works	26	54.2	14	29.2	40	83.4	8	16.6	48
Lumber Yards	12	75.0	4	25.0	16	100.0	0	..	16
Macaroni Factories	13	68.5	4	21.0	17	89.5	2	10.5	19
Machine Shops and Works	481	72.2	156	23.4	637	95.6	30	4.4	667
Mail Order Houses	67	87.0	10	13.0	77	100.0	0	..	77
Match Factories	73	76.1	18	18.7	91	94.8	5	5.2	96

	Extinguished Fire		Held Fire in Check		Total Satisfactory		Unsatisfactory		Total No. of Fires
	No.	%	No.	%	No.	%	No.	%	
Mattress Factories	643	70.6	251	27.5	894	98.1	17	1.9	911
Mercantile (Miscellaneous)	1089	83.0	199	15.1	1288	98.1	30	1.9	1318
Metal Reduction Plants	11	64.7	6	35.3	17	100.0	0	..	17
Metal Workers†	1308	64.8	626	31.1	1934	95.9	82	4.1	2016
Mining Property	2	40.0	2	40.0	4	80.0	1	20.0	5
Mirror Mfg.	22	88.0	2	8.0	24	96.0	1	4.0	25
Miscellaneous	441	75.5	119	20.4	560	95.9	25	4.1	585
Motion Picture Exchanges	53	78.0	12	17.6	65	95.6	3	4.4	68
Motion Picture Studios	40	78.5	11	21.5	51	100.0	0	..	51
Motion Picture Theatres	85	79.4	16	14.9	101	94.3	6	5.7	107
Multiple Occupancy	105	76.6	20	14.6	125	91.2	12	8.8	137
Munition Plants	25	42.4	24	40.7	49	82.7	10	17.3	59
Musical Instruments Factories	162	69.5	64	27.5	226	97.0	7	3.0	233
Office Buildings	108	88.5	14	11.5	122	100.0	0	..	122
Oil Cloth Works	30	47.6	26	41.3	56	88.3	7	11.7	63
Oil Clothing Factories	26	93.0	1	3.5	27	96.5	1	3.5	28
Oil Distributing Stations	2	50.0	2	50.0	4	100.0	0	..	4
Oil Refineries—Animal	4	50.0	3	37.5	7	87.5	1	12.5	8
Oil Refineries—Mineral	7	58.2	4	33.3	11	91.5	1	8.5	12
Oil Refineries—Vegetable	13	48.2	11	40.8	24	89.0	3	11.0	27
Optical Works	22	62.9	13	37.1	35	100.0	0	..	35
Packing Houses	204	70.8	79	26.8	283	97.6	11	2.4	294
Paint and Varnish Works	315	66.6	141	29.7	456	96.3	18	3.7	474
Paper Coating Mills	39	69.6	13	23.2	52	92.8	4	7.2	56
Paper Mills	703	52.5	516	38.5	1219	91.0	116	9.0	1335
Paper Working	414	77.1	110	20.5	524	97.6	12	2.4	536
Peanut Roasting Plants	6	54.6	2	18.2	8	72.8	3	21.2	11
Phonograph Works	34	58.0	14	28.0	48	96.0	2	4.0	50
Photo Camera and Film Mfg.	17	60.6	11	39.4	28	100.0	0	..	28
Photo Engraving and Studios	57	87.8	7	10.7	64	98.5	1	1.5	65
Picture Frame Mfg.	62	55.3	26	27.7	88	83.0	6	17.0	94
Piers and Wharves	22	52.4	17	40.5	39	92.9	3	7.1	42
Plumbers' Supplies	41	73.2	12	21.4	53	94.6	3	5.4	56
Potteries	61	64.2	26	27.4	87	91.6	8	8.4	95
Printing and Lithographing	1196	82.4	232	16.0	1428	98.4	24	1.6	1452
Prisons	4	40.0	4	40.0	8	80.0	2	20.0	10
Public Buildings	10	77.0	3	23.0	13	100.0	0	..	13
Pulp Mills	51	39.5	53	41.1	104	80.6	25	19.4	129
Pyroxylin Plastic Mfg. Fabricating	262	68.5	86	22.4	348	90.9	37	9.1	385
Radios and Accessories	63	84.0	10	13.3	73	97.3	2	2.7	75
Railroad—Misc. Property	5	31.2	10	62.5	15	93.5	1	6.5	16
Railroad—Repair Shops	4	44.5	5	55.5	9	100.0	0	..	9
Rayon Mills	29	85.4	4	11.8	33	97.2	1	2.8	34
Restaurants	179	75.0	57	23.8	236	98.8	3	1.2	239
Rice Mills	2	25.0	2	25.0	4	50.0	4	50.0	8
Rolling, Wire and Tube Mills	90	66.2	41	30.1	131	96.3	5	3.7	136
Roofing Works	47	37.3	69	54.7	116	92.0	10	8.0	126
Rooming and Lodging Houses	8	88.9	0	..	8	88.9	1	11.1	9
Rubber Cloth Factories	65	62.4	35	33.7	100	96.1	4	3.9	104
Rubber Reclaiming Works	22	56.4	9	23.1	31	79.5	8	20.5	39
Rubber Mills	299	56.3	206	38.7	505	95.0	27	5.0	532
Salt Works	2	50.0	2	50.0	4	100.0	0	..	4
Saw and Planing Mills	119	41.4	91	31.7	210	73.1	77	26.9	287
Schools—Colleges and Universities	16	84.3	3	15.7	19	100.0	0	..	19
Schools—Private	6	66.7	2	22.2	8	88.9	1	11.1	9
Schools—Public	8	61.6	2	15.4	10	77.0	3	23.0	13
Schools—Trade and Industrial	13	81.4	2	12.5	15	93.9	1	6.1	16
Shipyards	16	55.2	12	41.4	28	96.6	1	3.4	29
Shoddy Mills	274	66.0	118	28.4	392	94.4	23	5.6	415
Shoe Factories	990	75.0	282	21.4	1272	96.4	48	3.6	1320
Shoe Mfg. Accessories	105	70.0	38	25.4	143	95.4	7	5.6	150

	Extinguished Fire		Held Fire in Check		Total Satisfactory		Unsatisfactory		Total No. of Fires
	No.	%	No.	%	No.	%	No.	%	
Shoe Stores	84	87.5	12	12.5	96	100.0	0	..	96
Silk Mills	189	81.5	35	15.1	224	96.6	8	3.4	232
Smelting and Refining	7	70.0	3	30.0	10	100.0	0	..	10
Soap Manufacturing	59	72.9	19	23.5	78	95.4	3	4.6	81
Stables	23	74.2	8	25.8	31	100.0	0	..	31
Stamping and Sheet Metal Works	191	62.5	97	31.7	288	94.2	18	5.8	306
Starch and Glucose Works	15	53.6	5	17.9	20	71.5	8	28.5	28
Stone Working	3	100.0	0	..	3	100.0	0	..	3
Sugar Refineries	41	54.0	32	42.2	73	96.2	3	3.8	76
Tannery Class A**	21	41.2	25	49.0	46	90.2	5	9.8	51
Tannery Class B**	127	56.5	79	35.1	206	91.6	19	8.4	225
Tannery Class C**	18	43.9	18	43.9	36	87.8	5	12.2	41
Tannery Class D**	26	72.2	9	25.0	35	97.2	1	2.8	36
Tenant Manufacturing	1720	78.7	383	17.5	2103	96.2	86	3.8	2189
Theatres	95	76.0	23	18.4	118	94.4	7	5.6	125
Tobacco Factories	95	76.0	26	20.8	121	96.8	4	3.2	125
Tobacco Warehouses	8	66.7	3	25.0	11	91.7	1	8.3	12
Trunk Factories	43	71.7	10	16.7	53	88.4	7	11.6	60
Umbrella Mfg.	21	80.9	4	15.4	25	96.3	1	3.7	26
Vinegar Works	1	100.0	0	..	1	100.0	0	..	1
Wall Paper Factories	28	73.7	6	15.8	34	89.5	4	10.5	38
Warehouses	496	75.0	135	20.4	631	95.4	30	4.6	661
Waste and Batting Mills	389	60.5	224	34.9	613	95.4	30	4.6	643
Waste Paper and Rag Shops	258	64.9	120	30.1	378	95.0	20	5.0	398
Water Works	1	33.3	2	66.7	3	100.0	0	..	3
Weaving Mills	198	68.5	83	28.7	281	97.2	8	2.8	289
Window Shade Factories	17	73.8	4	17.4	21	91.2	2	8.2	23
Woodworker, Class A*	210	54.9	120	31.4	330	86.3	52	13.7	382
Woodworker, Class B*	205	52.8	145	37.4	350	90.2	38	9.8	388
Woodworker, Class C*	201	61.8	105	32.3	306	94.1	19	5.9	325
Woodworker, Class D*	135	56.7	79	33.2	214	89.9	24	10.1	238
Woodworker, Class E*	198	64.7	92	30.0	290	94.7	16	5.3	306
Woodworker, Class F*	46	59.7	27	35.1	73	94.8	4	5.2	77
Woodworker, Class G*	2	20.0	7	70.0	9	90.0	1	10.0	10
Woodworker, Class H*	88	78.6	23	20.5	111	99.1	1	.9	112
Woolen Mills	1193	69.9	437	25.6	1630	95.5	78	4.5	1708
Wool Scouring Plants	41	68.4	16	26.7	57	95.1	3	4.9	60
Wool Storehouses	34	69.4	12	24.5	46	93.9	3	6.1	49
Worsted Mills	102	66.3	52	30.8	154	97.1	15	2.9	169
Total	37,134		14,123		51,257		2,166		53,423

*The Woodworkers are classified as follows:

Class A. Interior Woodwork, builders' supplies (including veneer works).

Class B. Box Factories (including cigar boxes).

Class C. Miscellaneous Woodworkers. Steam power tenant Woodworkers. Woodworkers where there is a lack of detailed information as to class.

Class D. Sash, Door and Blind Factories.

Class E. Hard Wood Turning (wheels, pipes, novelties, bobbins, spools, etc., last and wood heel factories).

Class F. Pails and Woodenware (plates, wooden bowls, tubs, etc.).

Class G. Wood Flour Mills.

†Other Metal Working Occupancies are included under Agricultural Implements; Automobile and Bicycle Factories; Bolt, Nut and Screw Works; Electrical Appliances; Forge and Smithy; Foundries; Machine Works; Rolling, Wire and Tube Works; and Stamping and Sheet Metal Works.

**The Tanneries are classified as follows:

Class A. Sole Leather and Belting.

Class B. Upper Leather (Calfskins, Sheepskins, Morocco).

Class C. Patent Leather.

Class D. Skin Mills (Glove Leather).

Table No. 5—Classification of Unsatisfactory Sprinkler Fires by Occupancy.

	Water shut off sprinklers.	Generally defective equipment and unsprinklered portions.	Defective water supply or supplies.	Sprinkler system crippled due to freezing.	Slow operation of dry system or defective dry valve.	Slow or defective operation of high test heads.	Faulty building construction, concealed spaces, vertical openings.	Obstruction to distribution.	Hazard of occupancy too severe for average sprinkler equipment.	Sprinkler system crippled by explosion.	Exposure or conflagration.	Plugged heads.	Miscellaneous.	Total.
Abrasive Works	..	1	..	..	..	..	..	..	..	..	..	..	1	2
Agricultural Implements	4	1	..	..	..	..	..	1	..	..	..	..	..	6
Alcohol Distilleries	..	..	..	..	..	..	..	..	..	1	..	..	..	1
Aluminum Works	..	..	..	..	..	..	..	..	..	1	..	..	..	1
Amusement Places	2	..	..	..	..	..	..	..	..	..	..	1	..	3
Artificial Leather Mfg.	..	..	..	..	..	..	1	..	..	2	..	..	..	3
Asbestos Works	..	..	2	..	..	..	..	..	..	1	..	..	..	3
Automobile Mfg.	8	3	2	..	1	..	..	4	..	2	1	..	..	21
Automobile Body Mfg.	4	6	3	..	2	..	1	2	1	1	3	1	1	25
Auto Sales and Service	2	1	..	1	..	..	..	..	..	1	..	..	..	5
Bag Factories	1	..	..	..	..	1	..	1	..	..	..	1	..	4
Bakeries	4	1	..	..	..	..	1	..	..	..	..	..	2	8
Basket Factories	..	..	..	..	..	..	..	..	..	..	1	..	..	1
Battery Mfg.	2	..	..	..	..	..	..	..	..	..	..	1	..	3
Bolt, Nut, and Screw Works	1	2	..	..	..	..	..	..	..	..	..	..	..	3
Bottling Works	..	1	..	..	..	..	..	..	..	..	..	..	..	1
Braid Mills	..	1	..	..	..	..	..	1	..	..	..	..	..	2
Brass and Copper Works	1	1	..	..	..	..	..	..	..	..	..	..	1	3
Broom Factories	3	..	..	..	..	..	..	..	..	..	..	..	..	3
Button Factories	..	..	..	2	..	..	..	..	..	..	..	..	..	2
Candy Factories	4	..	..	1	1	..	2	..	1	..	1	..	1	11
Canneries	1	..	..	..	1	..	..	..	..	..	1	..	..	3
Car Houses	2	3	1	..	1	..	..	1	..	..	..	..	..	8
Car Works	2	1	..	..	..	..	1	1	..	..	..	..	..	5
Carpet and Rug Mills	4	2	3	..	..	..	..	2	..	..	..	..	..	11
Cement and Plaster Mills	1	1	..	..	1	..	..	..	..	..	..	..	..	3
Cereal Mills	..	2	1	..	..	..	..	1	..	4	..	..	..	8
Chemical & White Lead Wks.	3	6	..	..	..	..	..	..	5	8	..	..	1	23
Clothing Mfg.	6	2	2	1	..	..	4	2	..	..	2	1	2	22
Clubs—City	..	..	..	..	..	..	1	..	..	..	..	..	..	1
Coal and Wood Yards	..	..	1	..	..	..	..	..	..	..	..	..	..	1
Coffee and Spice Mills	2	..	..	..	..	..	..	1	..	1	..	..	..	4
Coffin and Casket Mfg.	2	..	..	1	1	..	1	..	..	..	..	..	..	5
Cooperage Plants	1	4	..	..	..	1	..	4	..	..	2	..	..	12
Cordage Works	5	5	1	1	..	..	..	3	..	..	..	..	1	16
Cork Factories	1	..	1	..	..	..	..	..	1	1	..	..	1	5
Cotton Gins	1	1	..	..	..	..	..	..	..	..	..	..	..	2
Cotton Mills	40	27	11	2	2	1	5	3	3	1	..	4	15	114
Cotton Seed Oil Mills	3	6	4	..	..	..	..	..	2	..	..	..	3	18
Cotton Warehouses	16	2	7	..	2	..	1	6	4	..	..	2	4	44
Cutlery Mfg.	1	1	1	..	..	..	..	..	..	..	..	..	..	3
Department Stores	9	3	1	..	2	..	1	2	..	..	2	..	1	21
Distilleries	1	..	..	..	..	..	..	..	..	1	1	..	..	3
Drug Mfg. and Warehouses	1	..	..	..	1	..	..	..	..	..	3	..	1	6
Dry Goods Stores	4	..	..	..	..	..	..	1	..	..	..	..	..	5
Dwellings	..	..	..	..	..	..	..	..	..	..	..	..	1	1
Dyeing, Bleaching, Finishing	7	3	1	..	1	2	..	2	..	..	1	1	1	19

	Water shut off sprinklers.	Generally defective equipment and unsprinklered portions.	Defective water supply or supplies.	Sprinkler system crippled due to freezing.	Slow operation of dry system or defective dry valve.	Slow or defective operation of high test heads.	Faulty building construction, concealed spaces, vertical openings.	Obstruction to distribution.	Hazard of occupancy too severe for average sprinkler equipment.	Sprinkler system crippled by explosion.	Exposure or conflagration.	Plugged heads.	Miscellaneous.	Total.
Electrical Appliance Mfg....	3	..	2	..	..	..	1	2	..	1	..	1	3	13
Electric Power and Light...	1	1	..	..	..	..	..	1	..	..	..	..	..	3
Excelsior Factories	..	..	2	..	1	..	..	..	1	..	..	..	..	4
Fertilizer Plants	2	1	..	..	1	..	..	..	..	..	..	..	..	4
Fiber Products	..	..	1	..	..	..	..	..	..	..	..	..	..	1
Flax and Linen Mills.....	1	..	..	..	..	..	..	..	..	..	..	..	..	1
Flour and Grist Mills.....	10	3	2	..	1	..	1	1	2	6	2	..	2	30
Forge and Smithy.....	..	..	..	..	..	..	..	1	..	..	..	1	..	2
Foundries	13	1	1	..	1	..	1	1	..	2	..	..	..	20
Fur Works	1	..	..	..	..	..	2	..	..	..	..	..	1	4
Furniture Factories	34	23	10	4	1	..	4	12	12	1	4	3	2	110
Furniture Stores	5	..	..	..	1	..	1	..	..	..	..	..	..	7
Garages	11	..	..	2	1	..	..	3	..	1	..	..	1	19
Garbage Reduction Plants..	1	..	..	..	..	..	..	..	..	..	..	..	..	1
Gas Works	..	1	..	..	..	..	..	..	..	..	..	..	..	1
Glass Factories	4	4	2	1	..	..	3	1	..	..	..	..	3	18
Glove Factories	1	..	..	..	..	..	..	..	..	..	..	..	..	1
Glue Factories	2	..	..	..	..	..	..	..	1	..	..	..	..	3
Grain Elevators	1	5	5	..	4	..	2	1	1	4	2	..	1	26
Groceries	5	..	1	..	1	..	1	..	1	1	..	..	..	10
Hardware Stores	2	..	..	..	..	..	..	..	..	..	..	..	1	3
Hat Factories	9	4	2	..	1	..	..	2	..	..	..	..	3	21
Hotels—Year Round	2	1	1	..	..	..	1	..	..	..	..	..	..	5
Hotels—Seasonal	..	..	..	..	..	..	1	..	..	..	..	..	..	1
Ice Houses	1	..	..	..	..	..	..	..	..	..	..	..	..	1
Idle and Vacant Property..	15	1	..	2	..	..	1	1	..	..	1	1	..	22
Insulated Wire Works.....	..	2	..	..	..	..	..	..	..	..	..	..	..	2
Jewelry Factories	3	1	..	2	..	..	1	..	..	..	..	..	..	7
Junk Shops	3	..	..	..	1	..	..	..	..	..	1	..	..	5
Knitting Mills—Cop Yarn..	1	1	3	..	..	..	..	1	..	1	..	..	..	7
Knitting Mills—Full Process	10	10	6	1	1	..	1	..	..	1	..	1	..	31
Lamp Shade Factories.....	..	..	1	..	..	..	..	..	..	..	..	..	..	1
Laundries	4	..	1	..	..	..	..	1	..	..	..	..	..	6
Lead Pencil Factories.....	..	..	..	..	..	..	..	..	..	1	..	..	..	1
Leather Working	1	..	1	..	1	..	..	1	..	..	..	..	1	5
Linoleum Works	..	8	..	..	..	..	1	2	7	..	..	..	..	18
Linseed Oil Works.....	1	1	..	..	..	..	1	..	1	2	..	2	..	8
Macaroni Factories	2	..	..	..	..	..	..	..	..	..	..	..	..	2
Machine Shops and Works..	17	6	1	1	..	1	..	..	..	2	..	2	..	30
Match Factories	2	..	..	..	..	..	..	..	2	..	..	..	1	5
Mattress Factories	12	2	..	1	..	..	..	2	..	..	..	..	..	17
Mercantile (Miscellaneous).	10	6	1	2	..	..	5	..	..	..	4	..	2	30
Metal Workers†	25	20	4	1	1	2	5	4	6	5	3	2	4	82
Mining Property	..	1	..	..	..	..	..	..	..	..	..	..	..	1
Mirror Mfg.	..	..	..	..	..	..	1	..	..	..	..	..	..	1
Miscellaneous	5	4	1	..	2	1	3	..	5	..	1	..	2	24
Motion Picture Exchanges..	..	..	..	..	1	..	..	..	2	..	..	..	..	3
Motion Picture Theatres...	2	1	..	..	..	..	..	1	..	1	1	..	..	6

	Water shut off sprinklers.	Generally defective equipment and unsprinklered portions.	Defective water supply or supplies.	Sprinkler system crippled due to freezing.	Slow operation of dry system or defective dry valve.	Slow or defective operation of high test heads.	Faulty building construction, concealed spaces, vertical openings.	Obstruction to distribution.	Hazard of occupancy too severe for average sprinkler equipment.	Sprinkler system crippled by explosion.	Exposure or conflagration.	Plugged heads.	Miscellaneous.	Total.
Multiple Occupancy	2	1	..	1	..	..	5	..	..	2	..	..	1	12
Munition Plants	2	..	..	1	..	..	..	..	4	2	..	..	1	10
Musical Instrum't Factories	1	4	..	..	..	..	1	..	..	..	1	..	..	7
Oil Cloth Works	..	..	..	..	..	..	..	1	6	..	..	..	..	7
Oil Clothing Factories	..	..	..	..	..	..	..	..	..	..	..	..	1	1
Oil Refineries—Animal	..	..	1	..	..	..	..	..	..	..	..	..	..	1
Oil Refineries—Mineral	..	..	..	..	..	1	..	..	..	..	..	..	..	1
Oil Refineries—Vegetable	2	..	1	..	..	..	..	..	..	..	..	..	..	3
Packing Houses	3	2	1	..	2	..	..	..	1	1	..	..	1	11
Paint and Varnish Works	3	3	5	..	1	..	3	1	..	2	..	..	..	18
Paper Coating Mills	1	..	..	..	..	..	..	2	..	..	..	..	1	4
Paper Mills	27	25	18	3	2	3	2	9	4	3	3	3	14	116
Paper Working	6	1	..	..	1	..	..	2	1	..	..	1	..	12
Peanut Roasting Plants	..	..	1	..	..	..	..	..	..	..	2	..	..	3
Phonograph Works	2	..	..	..	..	..	..	..	..	..	..	..	..	2
Photo Engraving & Studios	1	..	..	..	..	..	..	..	..	..	..	..	..	1
Picture Frame Mfg.	1	2	1	1	..	..	..	1	..	..	..	..	..	6
Piers and Wharves	..	2	1	..	..	..	..	..	..	..	..	..	..	3
Plumbers' Supplies	2	1	..	..	..	..	..	..	..	..	..	..	..	3
Potteries	3	2	1	1	..	..	..	..	..	1	..	..	..	8
Printing and Lithographing	10	5	1	..	..	..	2	1	1	..	3	..	1	24
Prisons	..	..	..	..	1	..	..	..	1	..	..	..	..	2
Pulp Mills	10	4	4	..	1	1	1	..	1	1	..	..	2	25
Pyroxylin Plastic Mfg. and Fabricating	3	1	3	1	1	..	2	2	17	6	2	..	..	38
Radios and Accessories	1	..	..	..	..	..	..	..	..	..	..	1	..	2
Railroad—Misc. Property	..	..	..	..	..	..	..	..	..	..	..	1	..	1
Rayon Mills	..	..	..	..	..	..	..	..	..	..	..	..	1	1
Restaurants	1	1	..	..	..	..	1	..	..	..	..	..	..	3
Rice Mills	..	1	1	..	..	..	..	..	..	..	..	..	2	4
Rolling, Wire & Tube Mills	..	1	..	..	1	1	1	..	..	..	..	1	..	5
Roofing Works	3	2	..	1	..	..	1	2	..	1	..	..	..	10
Rooming & Lodging Houses	1	..	..	..	..	..	..	..	..	..	..	..	..	1
Rubber Cloth Factories	2	1	..	..	..	..	..	..	..	..	..	..	1	4
Rubber Reclaiming Works	3	..	..	..	..	..	1	1	1	1	1	..	..	8
Rubber Mills	9	1	..	1	..	..	..	1	7	6	..	1	1	27
Saw and Planing Mills	19	15	7	1	5	1	6	4	8	..	5	1	5	77
Schools—Private	..	1	..	..	..	..	..	..	..	..	..	..	..	1
Schools—Public	1	1	..	..	..	..	1	..	..	..	..	..	..	3
Schools—Trade & Industrial	1	..	..	..	..	..	..	..	..	..	..	..	..	1
Shipyards	1	..	..	..	..	..	..	..	..	..	..	..	..	1
Shoddy Mills	6	3	7	..	1	3	1	1	..	..	..	..	1	23
Shoe Factories	19	8	3	..	1	1	2	3	..	3	5	..	3	48
Shoe Mfg. Accessories	3	2	..	1	..	..	..	..	..	..	..	..	1	7
Silk Mills	3	2	..	..	..	..	..	..	..	1	..	..	2	8
Soap Manufacturing	2	1	..	..	..	..	..	..	..	..	..	..	..	3
Stamping & Sht. Metal Wks.	4	5	1	..	1	..	2	1	..	1	2	..	1	18
Starch and Glucose Works	..	..	..	..	..	..	..	..	1	7	..	..	..	8

	Water shut off sprinklers.	Generally defective equipment and unsprinklered portions.	Defective water supply or supplies.	Sprinkler system crippled due to freezing.	Slow operation of dry system or defective dry valve.	Slow or defective operation of high test heads.	Faulty building construction, concealed spaces, vertical openings.	Obstruction to distribution.	Hazard of occupancy too severe for average sprinkler equipment.	Sprinkler system crippled by explosion.	Exposure or conflagration.	Plugged heads.	Miscellaneous.	Total.
Sugar Refineries	1	1	..	..	..	..	..	..	..	1	..	..	..	3
Tannery Class A**	1	1	..	1	..	..	..	..	..	..	1	..	1	5
Tannery Class B**	7	4	..	2	3	..	1	1	..	..	..	..	1	19
Tannery Class C**	1	..	1	1	..	..	1	..	..	..	1	..	..	5
Tannery Class D**	..	..	..	1	..	..	..	..	..	..	..	..	..	1
Tenant Manufacturing	49	9	2	4	1	..	3	3	2	1	7	2	3	86
Theatres	4	3	..	..	..	..	..	..	..	..	..	..	..	7
Tobacco Factories	1	1	..	..	..	..	..	..	1	..	1	..	..	4
Tobacco Warehouses	..	..	..	..	..	..	..	..	..	..	1	..	..	1
Trunk Factories	3	1	1	..	..	..	1	..	..	..	1	..	..	7
Umbrella Mfg.	..	..	..	..	..	..	..	..	..	1	..	..	..	1
Wall Paper Factories	..	..	1	..	..	..	..	1	1	..	1	..	..	4
Warehouses	11	4	3	..	1	..	3	2	3	..	..	..	3	30
Waste and Batting Mills	8	4	5	2	2	1	..	2	2	..	..	3	1	30
Waste Paper & Rag Sorting	12	3	1	1	..	..	..	..	1	..	..	..	2	20
Weaving Mills	1	2	2	1	..	..	..	2	..	..	..	..	..	8
Window Shade Factories	..	..	..	1	..	..	..	..	1	..	..	..	..	2
Woodworker, Class A*	13	10	5	1	2	1	2	6	1	3	3	1	4	52
Woodworker, Class B*	10	9	3	3	1	2	1	1	..	3	2	3	..	38
Woodworker, Class C*	6	6	3	..	..	..	1	3	..	..	..	..	..	19
Woodworker, Class D*	3	10	..	1	1	..	..	..	..	2	4	..	3	24
Woodworker, Class E*	6	1	1	..	2	1	2	..	1	..	1	1	..	16
Woodworker, Class F*	2	..	1	..	..	..	..	1	..	..	..	..	..	4
Woodworker, Class G*	..	..	..	..	..	..	..	..	..	1	..	..	..	1
Woodworker, Class H*	..	1	..	..	..	..	..	..	..	..	..	..	..	1
Woolen Mills	21	21	15	1	..	2	4	1	1	..	3	..	9	78
Wool Scouring Plants	..	1	1	..	..	..	1	..	..	..	..	..	..	3
Wool Storehouses	..	2	..	..	..	..	..	..	..	..	..	..	1	3
Worsted Mills	3	4	2	1	..	..	1	..	..	..	..	..	4	15
Total	692	391	194	59	67	27	109	131	125	104	87	44	136	2166

†See note on Metal Workers under Table No. 4.
*See detailed classification of Woodworkers as given in note under Table 4.
**See detailed classification of Tanneries as given in note under Table No. 4.

VOLUME XXVII. INDEX.

	Quarterly No.	Page No.
A		
Airplane Hangar Fires, Roosevelt Field, N. Y.	1	39
Alcohol Tank Fire, Westwego, La. *S. G. Peters*	2	145
Anderson, Ind., Store and Telephone Exchange Fire	4	316
Apartment House Fire, Brooklyn, N. Y. *Photograph*	4	288
Arlington, N. J., Pyroxylin Waste Fire	1	80
Atlantic City, The Revolution in Demolition of Buildings. *Editorial*	4	289
Atlantic City Meeting. *Editorial*	4	289
Auburn, Maine, Conflagration	1	59
Automatic Sprinklers, Annual Tables	4	365
Automatic Sprinkler Users Win Rate Case. *Decision of Missouri Public Service Commission*	2	98
B		
Bakery Fire Record	4	346
Birmingham, Ala., Department Store Fire. *South-Eastern Underwriters Association*	4	335
Blower and Exhaust Systems, Amendment to Regulations, Approval by Board of Directors	1	10
Board of Directors Meetings:		
May 29, 1933	1	8
June 26, 1933	1	8
January 20, 1934	4	293
Boston, Mass., Central Wharf Fire. *Photograph*	3	184
Brevoort Apartment House Fire, Brooklyn, N. Y. *Photograph*	4	288
Brooklyn, N. Y., Brevoort Apartment House Fire. *Photograph*	4	288
Brush Fire Disaster, Los Angeles. *Chief Ralph J. Scott*	3	194
Building Codes and Fire Prevention. *Frank Burton*	1	11
C		
Canadian Fire Losses, 1932. *Dominion Fire Prevention Association*	1	25
Central Wharf Fire, Boston, Mass. *Photograph*	3	184
Chlorine in Industry. *Robert E. Stone*	2	116
Cigarettes, Fire Hazard Tests with. *F. M. Hoffheins*	2	132
Cigarettes and Matches. *Editorial*	4	292
Conflagrations:		
Ellsworth, Maine, May 7, 1933	1	44
Auburn, Maine, May 15, 1933	1	59
Lowell, Mass., June 25, 1933. *Editorial*	1	5
Tillamook, Ore., Forest, Aug. 14, 1933	3	198
Hakodate Japan, March 22, 1934. *Editorial*	4	290
Country Clubs, Fire Record of	2	151
D		
Department Store Fire, Birmingham, Ala. *South-Eastern Underwriters Association*	4	335
Distilleries, Fire Record of	3	245
Distilleries, Whiskey. *Joseph G. Hubbell*	3	239
Drill Tower, Raleigh, N. C.	2	109
E		
Electrical Code, National, Amendments Approved by Board of Directors	1	9
Electric Generating Stations, Oil Hazards in. *George S. Lawler*	1	28
Ellsworth, Maine, Conflagration	1	44
Explosion, Gas Holder, Neunkirchen, Germany	3	250
Explosions, Molasses Tank. *C. A. Browne*	4	310
F		
Film Fire, Caguas, Porto Rico. *Editorial*	3	187
Fire Cause Trends	4	296
Fire Companies, Planning Inspection Work of. *Horatio Bond*	2	104
Fire Control for Passenger Vessels. *George G. Sharp*	3	215
Fire Department Field Demonstrations, Rural. *Willard B. Hall*	2	127
Fire Department, Legal Work in. *Editorial*	2	97

	Quarterly No.	Page No.
Fire Gases. *George E. Ferguson*....	2	110
Fire Hazard Tests with Cigarettes. *F. M. Hoffheins*.....	2	132
Fire Loss, U. S., 1932. *National Board of Fire Underwriters*.....	1	19
Fire Loss, U. S, 1933. *National Board of Fire Underwriters*.....	3	189
Fire Losses, Canadian, 1932. *Dominion Fire Prevention Association*	1	25
Fire Losses, U. S. *Editorial*.....	1	6
.....	3	185
Fire Losses, U. S. 1932-1933. *National Board of Fire Underwriters*	4	295
Fire Prevention and Modern Manufacturing. *H. L. Miner*....	4	303
Fire Prevention Week, 1933. *Editorial*	3	185
Fire Pumps, Revision of Regulations	4	293
Fire Record—Country Clubs.....	2	151
—Loss of Life by Fire 1930-1933	2	170
—Distilleries	3	245
—Tank Trucks	3	252
—Bakeries	4	346
Fires, Self-Extinguishing at Winnipeg and New Albany, Ind. *Editorial*	3	187
Flour and Feed Mills, Amendments to Regulations Approved by Board of Directors.....	1	10
Forest Conflagration, Tillamook, Ore. *Editorial*.....	2	95
Lynn F. Cronemiller.....	3	198
Forest Fire Danger, Measuring. *H. T. Gisborne*.....	4	323
Fort Wayne, Ind., Wood Shingle Roof Fires	1	79

G

Gas Holder Explosion, Neunkirchen, Germany	3	250
Gases, Fire. *George E. Ferguson*....	1	110
Gasoline Absorption Plant Fire, Long Beach, Cal.....	2	141

H

Hakodate, Japan, Conflagration. *Editorial*	4	290
Halifax, N. S., Pier Fire.....	3	276
Hangar Fires, Roosevelt Field, N. Y.	1	39

I

Inspection Work of Fire Companies, Planning. *Horatio Bond*	2	104

L

Large Loss Fires, 1933.....	3	190
Legal Work in the Fire Department. *Editorial*	2	97
Linoleum Factory Fire, Paulsboro, N. J.....	4	329
Long Beach, Cal., Gasoline Absorption Plant Fire.....	2	141
Los Angeles Brush Fire Disaster. *Chief Ralph J. Scott*.....	3	194
Editorial	2	95
Los Angeles, Legal Work in Fire Department. *Editorial*	2	97
Loss of Life by Fire—*Editorial*....	2	95
—1930-1933 ..	2	170
Loss of Life in Old Law Tenements, New York, N. Y. *Editorial*	4	291
Loss of Life Fires—Second Quarter 1933	1	88
—Third Quarter 1933	2	176
—Fourth Quarter 1933.....	3	281
—First Quarter 1934	4	361
Losses, Fire. (*See Fire Losses*)		
Lowell, Mass., Conflagration. *Editorial*	1	5
Lynchburg Transient Bureau Fire	4	301

M

Measuring Forest Fire Danger. *H. T. Gisborne*.....	4	323
Measurement of Fire. *Editorial*....	2	96
Missouri Public Service Commission, Decision in Sprinkler Rate Case	2	98
Modern Manufacturing, Fire Prevention and. *H. L. Miner*.....	4	303
Molasses. *Editorial*	2	96
Molasses Tank Explosions. *C. A. Browne*	4	310

N

National Electrical Code, Amendments Approved by Board of Directors	1	9
Neunkirchen, Germany, Gas Holder Explosion	3	250
New England Conflagrations. *Editorial*	1	5
New York, N. Y., Loss of Life in Old Law Tenements. *Editorial*..	4	291

	Quarterly No.	Page No.
O		
Oakland, Cal., Pier Fire	1	85
Oil Burning Equipments, Approval of Revised Regulations by Board of Directors	4	294
Oil Fire, Tiverton, R. I.	3	203
Oil Hazard in Modern Power Houses, The. *George S. Lawler*	1	28
Old Law Tenements, New York, N. Y., Loss of Life in. *Editorial*	4	291
P		
Passenger Vessels, Fire Control for. *George G. Sharp*	3	215
Paulsboro, N. J., Linoleum Factory Fire	4	329
Pier Fire, Central Wharf, Boston. *Photograph*	3	184
Halifax, N. S.	3	276
Oakland, Cal.	1	85
Planning Inspection Work of Fire Companies. *Horatio Bond*	2	104
Porto Rico Film Fire. *Editorial*	3	187
Power Houses, The Oil Hazard in Modern. *George S. Lawler*	1	28
Pyroxylin Hazard, The. *Editorial*	1	6
Pyroxylin Lacquer Finishes, Manufacture of	4	304
Pyroxylin Waste Fire, Arlington, N. J.	1	80
Editorial	1	6
R		
Raleigh, N. C., Drill Tower	2	109
Roof Fires, Wood Shingle, Fort Wayne, Ind.	1	79
Roosevelt Field, N. Y., Hangar Fires	1	39
Rural Fire Department Field Demonstrations. *Willard B. Hall*	2	127
S		
Self-Extinguishing Fires, Winnipeg and New Albany, Ind. *Editorial*	3	187
Sprinkler Tables, Annual	4	365
Sprinkler Users Win Rate Case. *Decision of Missouri Public Service Commission*	2	98
Store and Telephone Exchange Fire, Anderson, Ind.	4	316
T		
Tank Explosions, Molasses. *C. A. Browne*	4	310
Tank Truck Fire Record	3	252
Tank Truck Regulation. *Editorial*	3	186
Tank Trucks, Amendments to Suggested Ordinance Approved by Board of Directors	1	9
Technical Committee Procedure, Amendment to Regulations	1	10
Telephone Exchange and Store Fire, Anderson, Ind.	4	316
Telephone Exchange, Birmingham, Ala., Damage by Exposure Fire	4	343
Tenements, Old Law New York, N. Y., Loss of Life in	4	291
Tillamook Forest Conflagration. *Lynn F. Cronemiller*	3	198
Editorial	2	95
Tiverton, R. I., Oil Fire	3	203
Transient Bureau Fire, Lynchburg, Va.	4	301
V		
Vault in Birmingham, Ala., Department Store Fire	4	344
Vessels, Passenger, Fire Control for. *George G. Sharp*	3	215
W		
Westwego, La., Alcohol Tank Fire. *S. G. Peters*	2	145
Whiskey Distilleries. *Joseph G. Hubbell*	3	239
Wood Shingle Roof Fires, Fort Wayne, Ind.	1	79